New Scientist

WEEKLY 4 March 2023

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COSMIC CONUNDRUM
Space telescope finds galaxies that shouldn't be there

WHAT TO EXPECT
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Virtual event

Fermilab: Solving the mysteries of matter and energy, space and time

Join Fermilab senior scientist Don Lincoln as he explains what the particle physics facility in Illinois has taught us about our universe. Major discoveries made at the lab include the top and bottom quarks – and its future work might be critical for a "theory of everything". Online on 4 April at 6pm BST/1pm EDT. Early booking tickets are £14.

newscientist.com/events

Tour

Total Solar Eclipse 2023: Cruise Indonesia

Embark on a luxury schooner to view the solar eclipse on 20 April. Guided by local tour leaders, you will visit several of the remote islands explored by Alfred Russel Wallace in the 1850s as he, independently of Charles Darwin, conceived a theory of evolution through natural selection. The 10-day tour begins on 16 April, with prices from US$7100.

newscientist.com/tours

Podcast

Weekly

Podcast editor Rowan Hooper talks to writer Michael Molcher about his new book *I Am the Law: How Judge Dredd predicted our future*. Meanwhile, the team learns that tests in Chile suggest the technology we have sent to Mars may not be sensitive enough to find signs of life. Plus, ancient bows and arrows.

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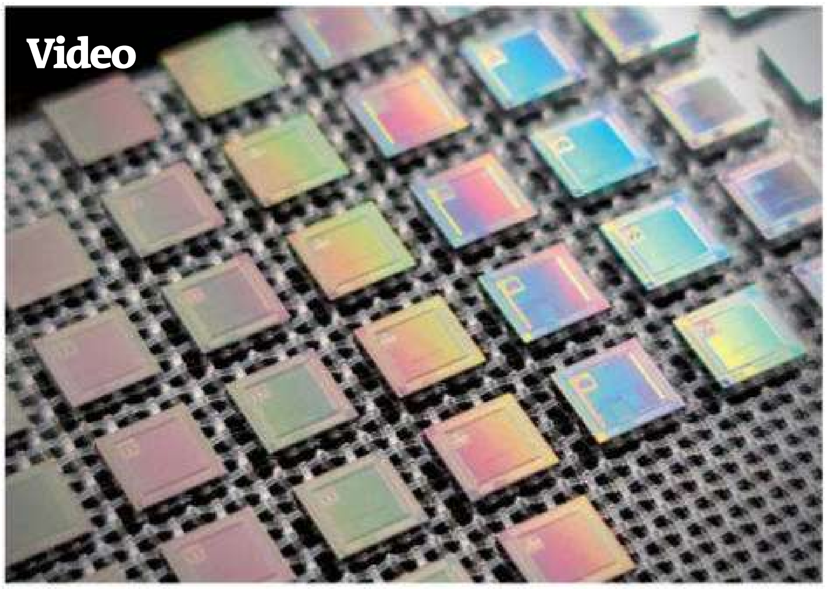


DOMINIC HART/NASA/AMES

Future computers Silicon transistors can store quantum bits

Video

Quantum revolution

On our YouTube channel this week, there is an interview with John Morton, founder and chief technology officer at UK firm Quantum Motion. He explains how silicon transistors can be used to store electrons as quantum bits, which could allow for the scaling up of quantum computers to design new materials and pharmaceutical drugs.

youtube.com/newscientist

Newsletter

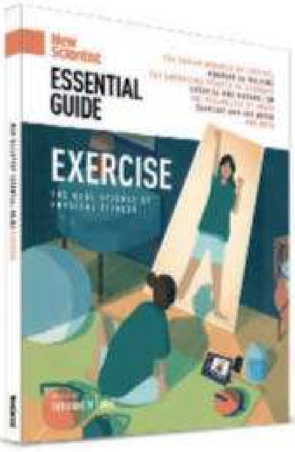
Wild Wild Life

Following a recent dispute in England over people's right to camp where they like, *New Scientist* news and digital editor Penny Sarchet wonders whether we should have rights to access the natural world – particularly given the positive benefits it has on health, happiness, memory and creativity.

newscientist.com/wild-wild-life

Newsletter

"Can it be right that, in England, the public can roam freely on only 8 per cent of the land?"



Essential guide

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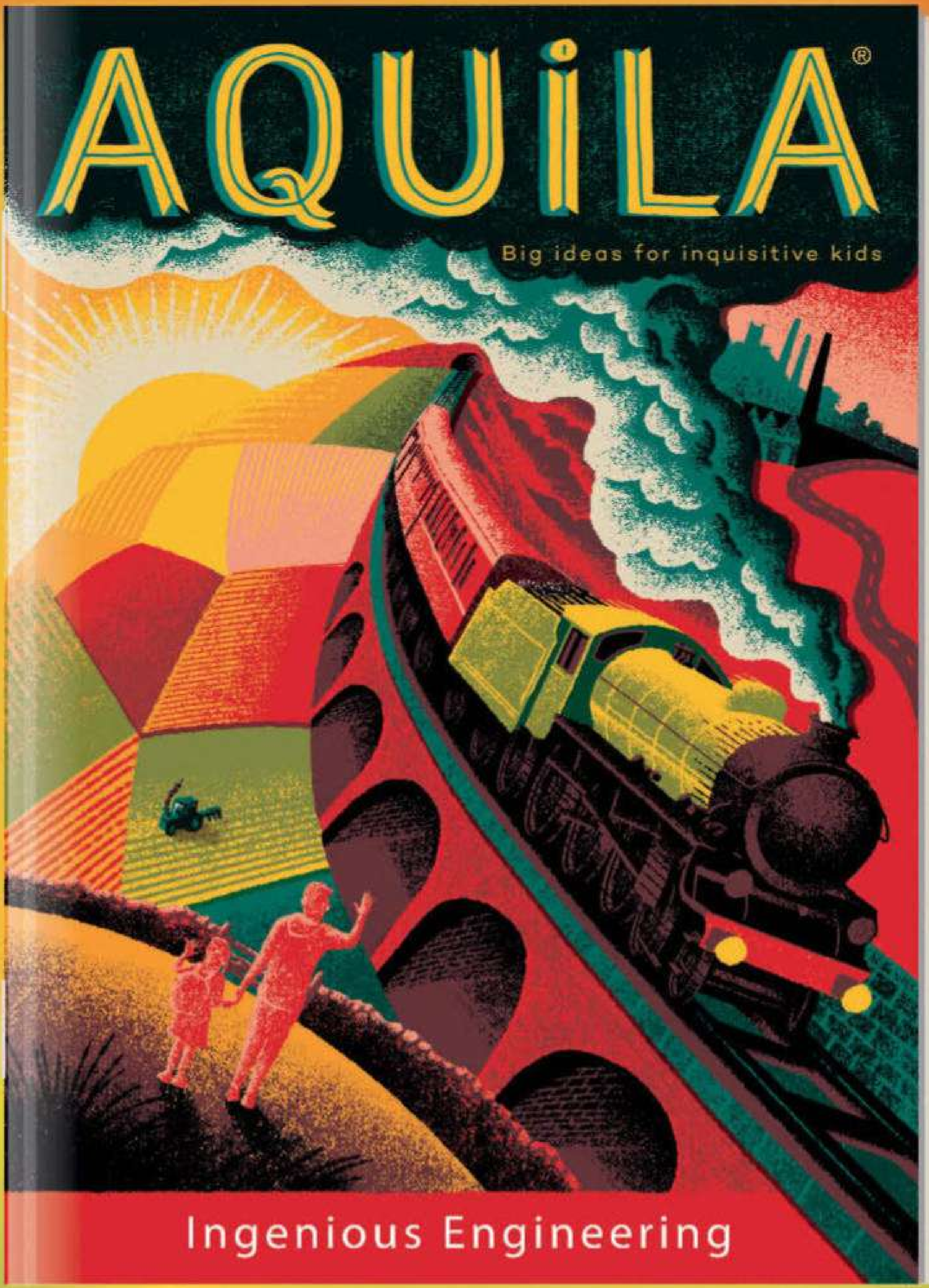

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Into the spotlight

Long-neglected chronic conditions are finally getting the attention they need

POST-VIRAL syndromes received little medical attention for decades, until the covid-19 pandemic triggered tens of millions of cases of long covid, leading to massive research efforts.

This week, we report on the growing evidence that long-term conditions like myalgic encephalitis/chronic fatigue syndrome (ME/CFS) are caused, wholly or in part, by viral infections (see page 14). Researchers have drawn links between ME/CFS and some herpes viruses, which infect us at a young age and stay in the body for the rest of our lives. There is also evidence that viruses play a role in fibromyalgia, a little-understood form of chronic pain.

Any improvement in our knowledge of these conditions is good news for those affected, of whom there are millions around the world.

How did such life-altering conditions come to be so neglected? It may be significant that they are more common in women than men, especially middle-aged women. One can't help but suspect that there was some sexism, however inadvertent, in doctors' tendencies to dismiss symptoms as psychosomatic. Even today, people with autoimmune conditions like multiple sclerosis, which are also far more common in women, often wait months or years for a diagnosis.

> **"There is growing evidence that long-term conditions like ME/CFS are caused by viruses"**

One reason long covid garnered so much attention was that many of the first to get it were medical workers. It seems doctors who might have dismissed strangers with hard-to-explain symptoms were less likely to ignore their colleagues. There is a lesson here about the importance of trusting a patient – one many doctors, happily, are taking to heart.

The media must also take its share of the blame. When ME/CFS was defined in the 1980s, it was casually dismissed by many journalists as "yuppie flu" or hypochondria. This wasn't just cruel, it was ill-informed: as early as 1994, *New Scientist* reported research indicating that viruses were the key to ME/CFS. Nearly three decades on, the message is finally getting through. ▮

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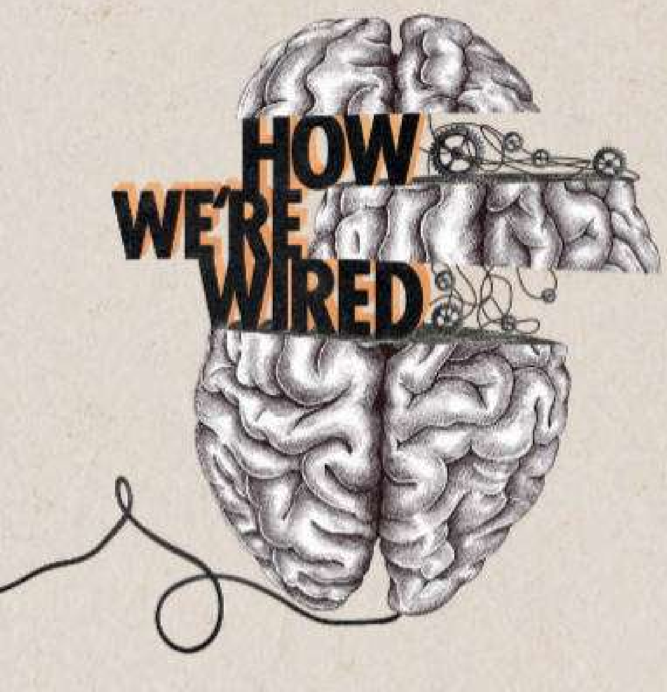

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News

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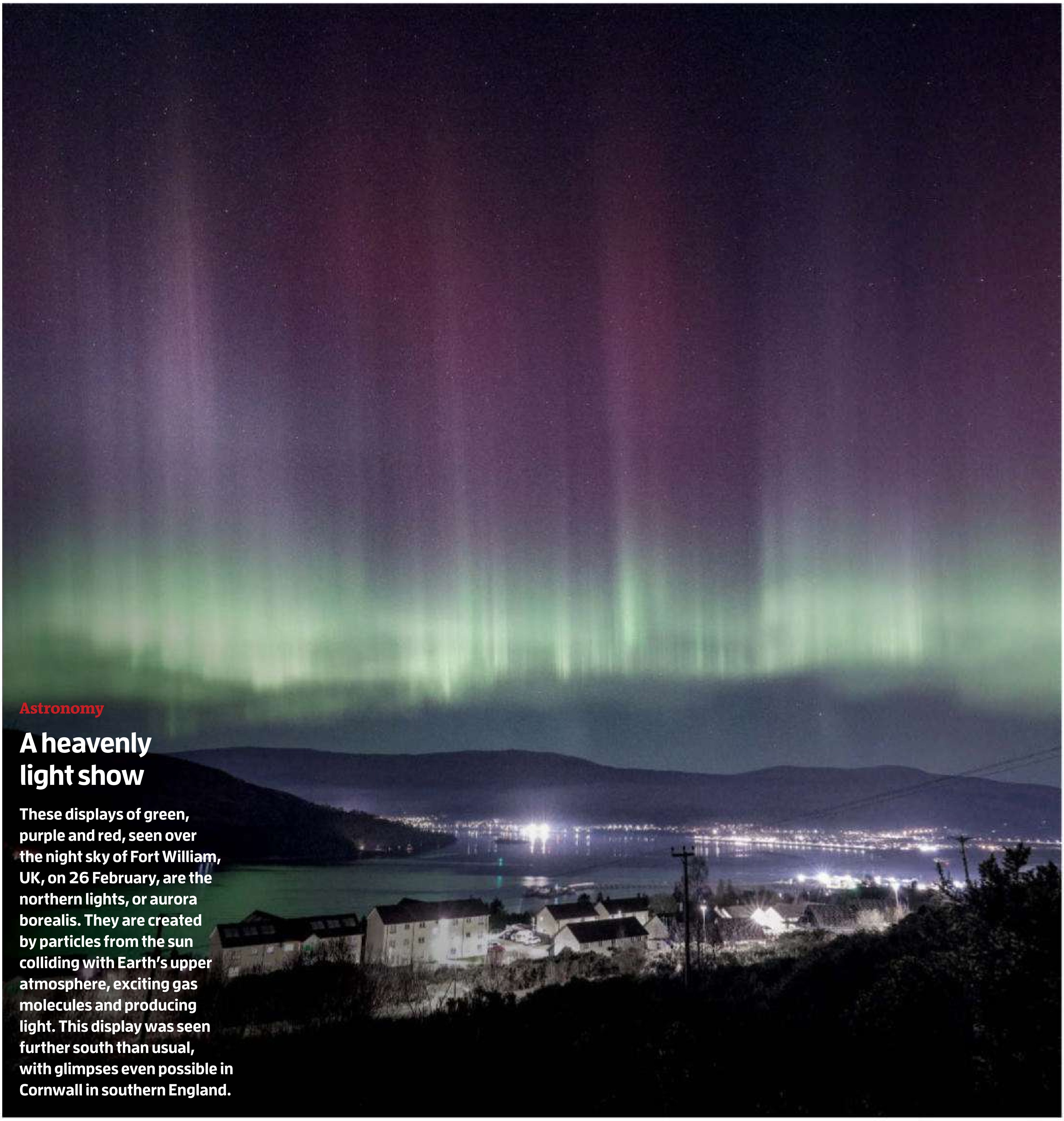


Astronomy

A heavenly light show

These displays of green, purple and red, seen over the night sky of Fort William, UK, on 26 February, are the northern lights, or aurora borealis. They are created by particles from the sun colliding with Earth's upper atmosphere, exciting gas molecules and producing light. This display was seen further south than usual, with glimpses even possible in Cornwall in southern England.

ANDREW MCGAVIN

Health

Why cholera is on the rise globally

More than 1 billion people across 43 countries are at risk of the bacterial infection, which can lead to severe dehydration and death in some cases, writes **Jason Arunn Murugesu**

CHOLERA cases are increasing, with 22 countries around the world experiencing an outbreak. After years of decline, incidences rose in 2022 due to vaccine shortages, climate change and escalating conflict, in a trend that is expected to continue.

During the first 29 days of January 2023, 26,000 cholera cases were reported throughout Africa – already reaching 30 per cent of the continent's total in 2022. Philippe Barboza at the World Health Organization (WHO) said at a press conference on 24 February that more than 1 billion people across 43 countries are at risk.

Overall, Malawi appears to be the worst-hit country, with the highest number of deaths, says Otim Patrick at the WHO. It reported just under 37,000 cholera cases and 1210 fatalities from 3 March 2022 to 9 February 2023.

This was triggered by a cyclone that hit in March 2022, says Patrick, which has led to wastewater contaminating drinking water supplies.

Cholera is spread by the ingestion of food or water that is contaminated with the bacterium *Vibrio cholerae*. When it enters the body, some types of *V. cholerae* release a toxin that interacts with the cells lining the surface of the intestine, leading to diarrhoea.

In some cases, this can result in severe dehydration and death. In Malawi, 3.3 per cent of people with cholera die of the infection, says Patrick. With treatment, this is typically around 1 per cent, he says.

In 2022, Malawi vaccinated millions of people in districts that were facing cholera outbreaks, says Patrick, but the cyclone means it has spread to all of its districts, putting unvaccinated people at risk.

Extreme weather, driven by climate change, means many more countries are at risk of wastewater contamination. Cyclone Freddy, which hit Mozambique on 24 February, is expected to exacerbate the country's cholera outbreak.

FREDRIK LERNERYD/AFP VIA GETTY IMAGES

A cholera treatment centre in Lilongwe, Malawi, in February

"Displacement due to conflict or natural disasters can force people into less sanitary areas"

30%

Proportion of cholera cases in Africa in the first 29 days of 2023, compared with total in 2022

1%

The typical cholera death rate with adequate treatment

Climate change-driven droughts in countries such as Kenya and Ethiopia have also forced people to rely on water sources that may be contaminated with *V. cholerae*, says Dounia Dekhili at UNICEF. Many people in these regions are malnourished, which affects their immune health, leaving them more vulnerable to severe cholera complications, she says.

Displacement, whether due to conflict in countries like the Democratic Republic of the Congo or disasters such as the earthquake that hit part of Syria on 6 February, can also play a role in cholera outbreaks if people are forced to move to less sanitary areas, or if already infected people take the bacteria with them, says Dekhili.

"The destruction of health facilities and infrastructures [in Syria] that bring water to people could lead to more cases," she says. The country reported more than 37,700 suspected cases in the cities of Idlib and Aleppo from 25 August 2022 to 7 January 2023 – 18 per cent of which were in people in displaced camps, according to the United Nations.

The unprecedented scale of the cholera outbreaks in 2022 – with 30 countries reporting cases, compared with an average of fewer than 20 in the previous five years – has also depleted global vaccine supplies, says Patrick. Only 37 million doses are available, said Barboza at the press conference.

The International Coordinating Group on Vaccine Provision, which manages the WHO's global vaccine stockpile, therefore recommends that at-risk people be vaccinated with a single dose of a cholera vaccine rather than the typical two doses. According to Patrick, the one-dose regimen gives only about one year of protection, compared with three years with two doses. If the outbreaks continue as they are, this year of protection might not be enough time to get them under control, he says.

Despite the fall in cases up to 2022, cholera has always been an issue, prompting the UN to publish a road map in 2017 to cut 90 per cent of cholera deaths globally by 2030.

According to Patrick, several countries have made progress here. The fact that Malawi has detected cholera outbreaks so quickly points to the work that officials have done to increase health surveillance, he says.

But with just seven years to go until 2030, Dekhili isn't convinced the UN's target will be reached. "There hasn't been enough investment in water infrastructure around the world to reach those goals," she says. ■

Environment

‘Forever chemicals’ targeted by US military with extreme water

James Dinneen

THE US military is to trial a method of destroying compounds known as “forever chemicals” by mixing water and hot air under pressure. The tests will be carried out on contaminated groundwater on air force and navy bases.

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a class of synthetic chemicals used since the 1940s that can be toxic to humans at very low concentrations. They are used to create coatings and foams that resist heat, oil and water, and have been found in air, soil and water all over the world, prompting clean-up efforts. But PFAS don’t break down easily and are difficult to destroy.

PFAS contamination is extensive at US military bases, where foam containing the chemicals has been widely used to put out fires. The US Department of Defense (DOD) has put billions of dollars into finding alternatives to the foam, as well as developing better ways to destroy PFAS to prevent the chemicals going to landfills, where they can leach out into soil and water again.

Existing incineration methods may be able to destroy some types of PFAS, but can also cause further contamination. This has made the practice controversial and the DOD temporarily suspended it in 2022. The department now plans to assess a newly developed PFAS-destroying system designed by a company called 374Water. The system will be tested on two air force bases and one navy base, treating PFAS from contaminated groundwater as early as autumn 2023. The DOD is still deciding which locations will host the tests.

Doug Hatler, 374Water’s chief revenue officer, says the company’s system works by mixing a slurry of water and contaminated material with hot air within a high-pressure reaction chamber. At temperatures above 374°C, the slurry reaches a “supercritical” state where it behaves both like a liquid and a gas. This is called supercritical water oxidation, or SCWO.

“The water becomes dissociated,” says Igor Novosselov at the University of Washington in Seattle, who isn’t involved with 374Water. It mixes with the air to generate loose molecules made up of a single hydrogen and oxygen atom. These molecules can then cleave the carbon-fluorine bonds that make PFAS so tough. “[The chamber] is a very aggressive environment,” he says.

374°C

Temperature of “supercritical” water used to destroy chemicals

At the military bases, the system will treat a concentrated mixture of water and absorbent materials used to filter PFAS out of the groundwater.

The current system can fit inside a shipping container and process slurry at around the same rate as a low-pressure garden hose, or over 5600 litres per day. A larger unit in development will be able to process five times as much waste, but Hatler says that is still a relatively small volume, and the system is best suited for concentrated waste streams.

The smaller system uses 300 kilowatt-hours of electricity per day, although Hatler says the larger system may instead be able to generate 300 kilowatt-hours daily by recycling the heat produced when breaking down the waste. “The waste actually becomes the fuel,” he says.

Novosselov says lab tests on SCWO show it can destroy even the toughest PFAS, but reactions may be less efficient with more complex, real-world waste at larger scales. ▮

Conservation

Stripy wind turbines could reduce fatal seabird collisions

THE number of seabirds killed by colliding with wind turbines could be cut by painting black-and-white stripes on the blades and poles, say researchers.

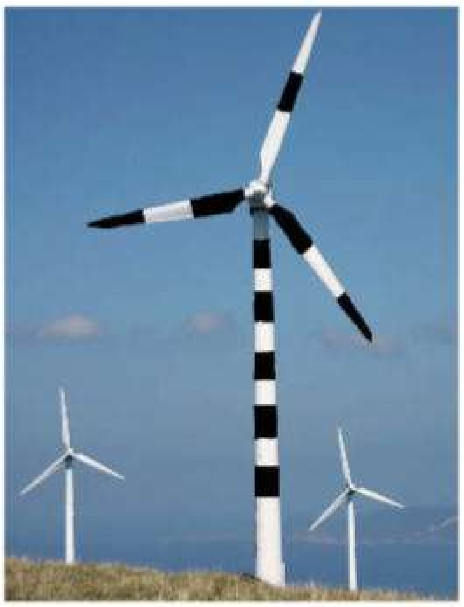
Graham Martin at the University of Birmingham, UK, and Alex Banks at Natural England, a public body that has a say in planning applications for offshore wind farms in England, wanted to devise a pattern that could be easily painted onto turbines to reduce their impact on bird life.

Between 140,000 and 328,000 birds are killed each year by onshore wind turbines in the US, according to one estimate. It is harder to tell how many birds are killed by offshore turbines each year, says Martin, as they fall into the ocean.

A previous study, published in 2020, looked at the effect of painting a single blade black on four onshore turbines in Norway. Bird collisions were reduced by 70 per cent compared with all-white turbines nearby.

Martin believes that further improvements could have an even greater impact. Based on analysis of previous studies into bird vision and bird collisions with wind turbines, the two researchers came up with a series of guiding principles to aid their design of a turbine that would harm fewer birds (*Global Ecology and Conservation*, doi.org/jx52).

“Most birds do not see too much fine detail in their vision – especially compared to humans,” says Martin, so any design shouldn’t be too complex. Many collisions occur in low light, so the design should be easy to decipher in the dark, while high internal contrast would help the turbine stand out against different backgrounds, such as a cloudy or sunny sky.



UNIVERSITY OF BIRMINGHAM

Illustration of the proposed turbine design to reduce collisions with birds at sea

In low levels of light, black-and-white patterns are best, says Martin. “In the dark, a red-and-white pattern would rapidly look like shades of grey,” he says.

The design hasn’t yet been tested, but Martin hopes that manufacturers will consider it, particularly as it would be easy and cheap to implement. “I think people are starting to take the issue seriously now,” he says. ▮

Jason Arunn Murugesu

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Environment

River Oder could be heading for repeat of 2022 ecological disaster

Madeleine Cuff

MARCIN BIELECKI/EPA-EFE/SHUTTERSTOCK

Dead fish being cleared from the river Oder in August 2022

AN ALGAL bloom that killed hundreds of thousands of fish in the river Oder between Germany and Poland in 2022 could reappear this summer with devastating consequences, scientists have warned.

About 360 tonnes of dead fish were hauled from the Oder – which runs for 840 kilometres along the German-Polish border – between July and August last year following a huge bloom of the toxic alga *Prymnesium parvum*. The European Commission described it as "one of the largest ecological disasters in recent European river history".

P. parvum is usually found in the brackish waters of estuaries. Scientists are unsure how it made its way to the Gliwice canal in Poland, a spur of the Oder that lies hundreds of kilometres from the coast and where the bloom is thought to have originated. However, now the alga is present in the waters, a fresh bloom could appear in the Oder or nearby rivers if conditions are right, scientists fear.

"That's one of the main concerns that we have: that it reoccurs in this river, but also that it could spread to other polluted rivers," says Gary Free at the European Commission's Joint Research Centre (JRC), which has published a study into the 2022 fish deaths in the Oder.

The river's poor water quality provided an "ideal soup" for *P. parvum* to bloom, Free and his colleagues concluded. Due to discharges from agriculture and waste-water sites, the Oder was already suffering from excess levels of nitrogen and phosphorus, nutrients that make it possible for algal blooms to develop.

The problem was compounded by successive heatwaves and a long drought during July and August 2022, which depleted water levels throughout the river and concentrated pollution. Discharges of salty waste water from industrial sites near the Gliwice canal then caused a surge in the river's salt levels, allowing the algae to bloom.

Alongside the huge numbers of fish that were killed in the event, populations of invertebrates such as mussels and snails were also severely affected, says Dietrich Borchardt at the Helmholtz Centre for Environmental Research in Germany. These filter-feeders usually help to control algal blooms, so the drop in their numbers leaves the river more susceptible to another bloom this summer and beyond, he says.

The Oder needs to go into "intensive care" to prevent further blooms, says Free, with urgent work required to tackle industrial pollution along the river and reduce nutrient loads. For example, the JRC recommends that authorities should be able to pause industrial discharges of salty waste when the threat of an algal bloom is high.

Borchardt believes a wholesale change in the rules governing industrial discharges will be necessary to protect river health in the future, especially as European summers become hotter and drier under climate change. ▮

Technology

Video games have been getting perspective wrong

A WAY of transforming digital images so they better reflect how our eyes see could make video games seem more realistic.

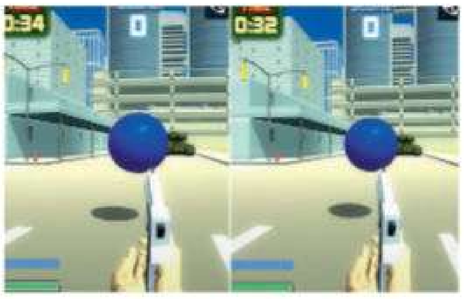
When you snap a picture of the moon, it often looks smaller in the photo than you expect, because we process images in a different way to cameras and computers.

When representing three-dimensional space on a flat screen, computer graphics rely on an artistic approach called linear perspective. It gives the illusion of depth by making parallel lines in a scene converge as they get further away, so distant objects seem smaller.

Human vision doesn't work like that, says Robert Pepperell at Cardiff Metropolitan University, UK. Each of the eyes projects light onto a curved retina, and their joint field of view is much wider than a photo. Objects we focus on also appear bigger than those in our peripheral vision, which is why we perceive the moon as larger than it seems in photos.

Pepperell and his colleagues have developed software that uses a mathematical model to mimic how the brain "bends light" and alters the geometry in an image.

They showed 195 people images from a game called *Hammer 2* that were either in the default linear perspective or were adjusted to be in natural perspective.



ROBERT PEPPERELL

A ball appears larger in natural perspective (far left) than in linear perspective

Participants had to guess how far away a target ball shown in the game was in 72 images. They often overestimated distances, but were better at guessing them in natural perspective than they were in linear perspective (psyarxiv.com/7xack).

Pepperell says perspective tweaks like this could make video games and movies more immersive and improve training simulators and architectural models. ▮

Edd Gent

Oceanography

Voyage into the unknown

Giant research vessel Falkor (too) is setting off on a mission to seek hydrothermal vents and undiscovered life forms along the mid-Atlantic ridge, reports **Ashley Balzer Vigil**

SCHMIDT OCEAN INSTITUTE

THE most advanced research vessel ever is about to set sail on its inaugural 40-day mission to look for never-before-seen creatures in the deep sea and shed light on how life may have arisen elsewhere in the universe.

The 110-metre-long ship Falkor (too), previously called the Polar Queen and dedicated to offshore industry, has undergone a 17-month refit to deck it out with scientific equipment.

"The ocean is so poorly understood, and we're on a mission to help change that"

As *New Scientist* went to press, the ship was due to depart from San Juan, Puerto Rico, on 3 March to look along the mid-Atlantic ridge, where the movement of tectonic plates creates tears in the seabed. It will search for unusual kinds of hydrothermal vents – seabed fissures that emit geothermally heated water – and the strange forms of life they host.

Decades after a "lost city" of chimney-like hydrothermal vents was discovered in the Atlantic Ocean, there are still only a few similar sites known, says expedition leader David Butterfield at the Cooperative Institute for Climate, Ocean and Ecosystem Studies at the University of Washington in Seattle.

The Schmidt Ocean Institute in Palo Alto, California, has kitted out Falkor (too) – which replaces a smaller ship called Falkor – with about 30 types of oceanographic, navigational and atmospheric sensors. There are also eight laboratories, including a cold lab, a seawater lab, a computational electronics lab and a robotics lab, and accommodation for nearly 100 people, but finding new vents won't be easy.

"When people think of hydrothermal vents, they often picture 'black smokers'," says Butterfield. "But the ones we're looking for are completely different, and they're much harder to find because they don't release those billowing plumes of smoke."

Once they arrive at the mid-Atlantic ridge, the teams on board will use sonar to map out the terrain. They will also send out autonomous underwater vehicles (AUVs) to search for chemical signatures from the reactions between seawater and hot magma seeping up through fissures. The AUVs will conduct their own high-resolution mapping to identify vent-like structures on the sea floor.

If the weather gets rough, there are two openings in the hull called moon pools through which scientists can deploy these vehicles without going on deck.

Once the researchers have identified promising locations, they will explore them using a remotely operated vehicle called SuBastian while watching on banks of screens on the ship. SuBastian can reach 4500 metres below the surface, which is deeper than the ocean at the mid-Atlantic ridge. High-resolution footage of its dives will be live-streamed so researchers and the public alike can see the first glimpses of any new creatures found near vents.

Of particular interest to the mission are hydrothermal vents in areas known as oceanic core complexes, where Earth's tectonic plates are moving apart so slowly that instead of magma solidifying into a thick layer of volcanic rocks, Earth's mantle – the layer between its core and external crust – becomes exposed to seawater.

A chemical reaction called serpentinisation occurs between the water and mantle rocks at vents, producing hydrogen, methane and other organic compounds. This allows microbes to rely on chemosynthesis, using chemical energy to drive their metabolism. It also enables animals that consume the microbes to live there even though no sunlight reaches them.

"We're interested in how the chemistry, microbiology and resulting animal communities are linked to the geology of their habitat," says Julie Huber at Woods Hole Oceanographic Institution in Massachusetts, who is part of the expedition.

4500m

Depth to which remote-controlled vehicle SuBastian can dive

Falkor (too) will be able to host dozens of researchers, as well as the deep-diving, remotely operated vehicle SuBastian (top, right), and will create detailed maps of the sea floor's features

Analysing the impact of serpentinisation on habitats also offers a way to study the possible genesis of life, she says.

"The serpentinisation process we aim to study is also happening elsewhere in our galaxy, including potentially deep beneath the icy crust on Saturn's moon Enceladus," says Huber. The fact that organic chemical building blocks of life can form without input from living creatures "has potential implications for how life first arose on Earth and how it may be supported elsewhere in the universe", says Huber.

To help study this, SuBastian will collect samples from the sea floor, "including seawater, hydrothermal vent water samples, rocks and small animals like snails, mussels or shrimp that live around vents", says Butterfield. The researchers will analyse many of these in the cold lab, which is chilled to about 5°C to allow work on temperature-sensitive samples from the deep sea.

The ship's missions may transform our understanding of the ocean, says Jyotika Virmani, executive director of the Schmidt Ocean Institute. "This year, we will explore several other kinds of hydrothermal vents, investigate octopus breeding grounds, test technology related to microplastics, study vertical coral reefs and much more. The ocean is so poorly understood, and we're on a mission to help change that." ■

Health

Single injection protects babies against RSV

Michael Le Page

PARENTS with babies could soon be offered an antibody injection around the start of winter that will help protect their child against the respiratory syncytial virus over the entire season, when RSV infections peak. There is currently no option available for protecting healthy babies against the virus, which can cause serious and sometimes deadly infections in infants less than a year old.

A trial involving 3000 infants has shown that this factory-made antibody, called nirsevimab, is safe and lowers the risk of babies needing medical attention for severe RSV infections by 79 per cent over the 150 days after the injection. It reduces the risk of hospitalisation by 77 per cent over the same period. The results were presented at a conference on RSV in Lisbon, Portugal, on 23 February.

"This is very special, because there's been a search for a vaccine or something to prevent RSV disease in healthy infants," says Tonya Villafana at AstraZeneca, who led the development of nirsevimab. "They can get very sick."

Infants are most at risk from infections by the respiratory syncytial virus

MIKE KEMP/GETTY IMAGES

In older children and adults, RSV infections typically cause no more than cold symptoms, but in the very young and very old, infections can be much more serious. Around 100,000 children die from RSV every year worldwide. In high-income countries, deaths are rare, but many babies require medical care because of RSV.

Nirsevimab has already been approved as a preventative treatment for all babies – not just vulnerable ones – in the European Union and the UK on the basis of initial results from the first 1500 babies. Other countries, such as the US, have been waiting for the full trial results, says Villafana.

However, cost will be a major issue in determining how widely nirsevimab is used globally. Antibody treatments tend to be extremely expensive because they are difficult to manufacture and medical authorities in some countries won't recommend the use of nirsevimab if the cost is too high. AstraZeneca hasn't yet announced pricing.

In England, nirsevimab would have to be priced about £60 per dose or less to be cost-effective, according to an estimate by Katherine Atkins at the London School of Hygiene & Tropical Medicine and her colleagues. "We are calculating the highest price per dose that England should be willing to purchase nirsevimab for," says Atkins.

In lower-income countries, the price would have to be even lower. In Vietnam, for instance, the price would have to be around $5 for it to be cost-effective, says Lien Anh Ha Do at the Murdoch Children's Research Institute in Australia. ■

Long covid

Rethinking chronic conditions

Long covid has shone a spotlight on the role of viruses in other conditions, like chronic fatigue syndrome, reports **Michael Marshall**

MILLIONS of people worldwide may have experienced long covid, with some having symptoms that have lingered for several years. However, while the number of cases is exceptional, the syndrome itself is not.

Long covid is one of many chronic conditions that can be triggered, at least in part, by infections, mostly by viruses. A surge of interest in long covid has helped us gain an improved understanding of what causes some of these conditions, from the role of herpes viruses in myalgic encephalitis or chronic fatigue syndrome (ME/CFS) to different viruses' potential effects in the onset of fibromyalgia, a condition that causes chronic pain throughout the body as well as other symptoms, like fatigue.

The scale of the long covid pandemic is staggering. A recent analysis of multiple studies, led by Hannah Davis at the Patient-Led Research Collaborative in New York, offered a "conservative" estimate that 10 per cent of all infections caused by the SARS-CoV-2 coronavirus result in long covid. Given there have been 755 million confirmed cases of covid-19, this implies at least 75 million incidences of long covid.

SICK
STILL
FIGH
DECLARE AN EMERGENCY FOR LONG COVID AND ME
#ME ACTION

BRYAN OLIN DOZIER/NURPHOTO/SHUTTERSTOCK

A chronic conditions protest in Washington DC, last September

Long covid causes a wide range of symptoms, including brain fog, shortness of breath and post-exertional malaise. Exactly why it occurs is unknown, but there are multiple potential causes. Many people with long covid have ongoing disruption to their immune system, whether it be overactive or suppressed, which may contribute to the symptoms. Microscopic blood clots have been seen in some people, which may block and damage the smallest blood vessels, potentially explaining their fatigue. And some people may have persistent coronavirus infections that remain in the body.

755
million confirmed cases of covid-19 worldwide so far

10%
Rough proportion of covid-19 cases that result in long covid

75
million long covid cases are likely to have occurred globally

This array of potential causes may mean there are several kinds of long covid – including post-intensive care and post-viral fatigue syndromes – each involving different mechanisms and combinations of symptoms. But long covid itself didn't come as a surprise. "I think it was quite reasonable to expect SARS-CoV-2 to cause chronic problems," says Jackie Cliff at Brunel University London. That is because other coronaviruses, such as those that cause severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), have triggered long-term problems.

Nevertheless, long covid has drawn researchers' attention to other conditions that can commonly occur after a viral infection, some of which have been neglected for decades.

Viral triggers

One condition that was garnering increased scientific attention before the covid-19 pandemic is ME/CFS – and long covid has raised its profile further. The most common ME/CFS symptoms include near-constant tiredness, even after sleep, and taking a long time to recover following exercise. This has considerable overlap with long covid: a study published in 2022 of 465 people with long covid found that 58 per cent of them met the criteria for ME/CFS.

Some have long suspected that ME/CFS is triggered by a viral infection, but pinning down the culprit has been hard, says Bhupesh Prusty at the University

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of Würzburg, Germany. “If you ask any patient, they always say it started with flu-like or cold-like symptoms,” he says. But by the time ME/CFS has developed and doctors are investigating, there is no trace of the original virus.

Prusty thinks ME/CFS originates in early childhood, when most people are infected by human betaherpesvirus 6B (HHV-6B), which causes a mild illness lasting a few days. “Afterwards, the virus stays in our body for the rest of our lives,” says Prusty. Later in life, the virus can become reactivated – and it is this that Prusty and some others believe causes ME/CFS.

“If you ask any ME/CFS patient, they always say it started with flu-like or cold-like symptoms”

In a 2021 study, Cliff and her colleagues took monthly saliva samples from 30 people with ME/CFS and 14 people who didn’t have the condition. Those with ME/CFS had higher levels of HHV-6B and another herpes virus, HHV-7, than those without. In people whose symptoms fluctuated over time, more severe symptoms were associated with higher levels of HHV-6B and HHV-7.

In 2022, Prusty and his colleagues studied post-mortem tissue samples from three people who had been diagnosed with ME/CFS, plus three who hadn’t. They only found signs of HHV-6B activity in the brain and spinal cord of those who’d had ME/CFS.

“The virus doesn’t have to be completely active [and] doesn’t have to produce viral particles,” says Prusty, who describes what the team saw as localised infections. This limited viral activity seems to be enough to cause chronic symptoms.

Prusty thinks reactivated herpes viruses may also be a factor in long covid, specifically in cases where symptoms last beyond three months or even for years. In line with this, in 2022, Eirini Apostolou at Linköping University, Sweden, and her colleagues showed that people had higher levels of antibodies against the herpes viruses EBV, HHV6 and HERV-K in their saliva three to six months after becoming infected with SARS-CoV-2, suggesting that the herpes viruses were reactivated after they caught the coronavirus. This was particularly true for those who also had ME/CFS.

Just as long covid and ME/CFS overlap, so do ME/CFS and fibromyalgia. In 2022, Manuel Martínez-Lavín at the National Institute of Cardiology Mexico in Mexico City and his colleagues showed that 47 per cent of people with either ME/CFS or fibromyalgia actually fit the criteria for both conditions.

Unlike ME/CFS, where viruses may be responsible, in fibromyalgia they could be one of multiple causes. “Infection induces fibromyalgia in a subgroup of fibromyalgia patients,” says Martínez-Lavín. “Psychological stress, physical trauma and autoimmune illnesses are other recognised triggers.”

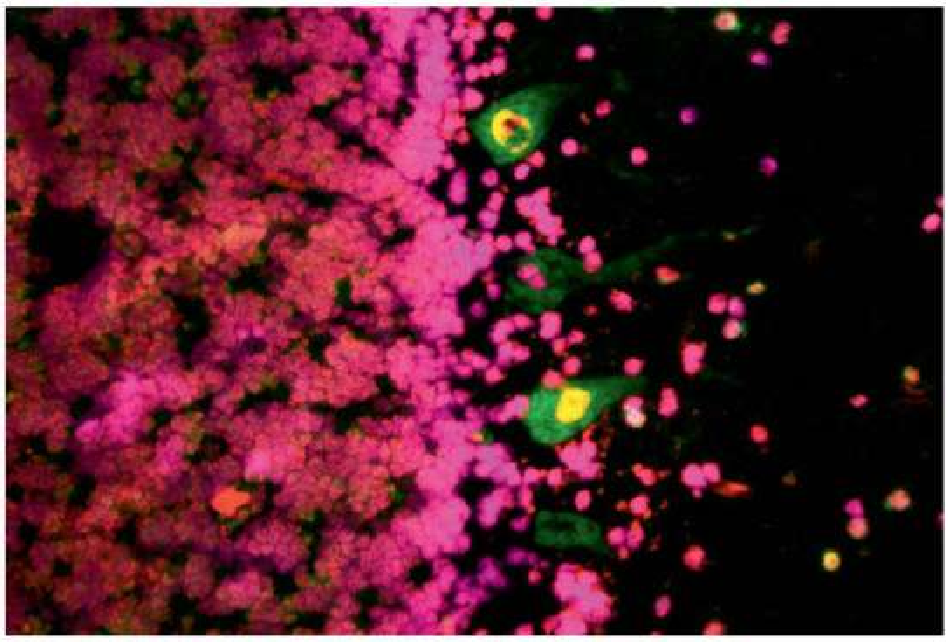
X-rays can be used to examine the lungs of people with covid-19

ERNESTO BENAVIDES/AFP VIA GETTY IMAGES

But a picture is forming of how viruses may give rise to the condition. Martínez-Lavín thinks the key to fibromyalgia lies in the dorsal root ganglia, a set of 31 nerve clusters dotted along the spine. Many pathogens are able to infect them, including herpes viruses, the hepatitis C virus and SARS-CoV-2.

When the neurons’ normal function is disrupted, Martínez-Lavín thinks they may send erroneous signals to the brain, causing the sensation of pain where no tissue damage exists. Studies have found correlations between fibromyalgia and viral infections such as hepatitis C, and a small study in 2022 suggested that antiviral drugs targeting chronic hepatitis C may reduce fibromyalgia symptoms in some people.

HHV-6B infection (yellow) of human brain neurons (green)



BHUPESH PRUSTY

While the mechanisms of conditions like long covid, ME/CFS and fibromyalgia are becoming clearer, many questions remain unanswered. We don’t know why certain viral infections are more likely to cause chronic conditions than others or what makes some people more susceptible to developing these conditions.

A long-standing challenge has been the lack of diagnostic tests that can reliably distinguish people who have chronic fatigue and pain conditions from people who don’t by measuring a particular molecule in a person’s blood or a similar bodily substance.

In the longer term, digging into the physiological mechanisms of these conditions should suggest the best treatment options. In the meantime, Cliff says sociological change is the most important preventative step we can take.

“I think personally there needs to be a bit of a groundswell change in the way we view illness,” she says. “There is evidence that overexertion early on after an acute infection is more likely to lead to chronic ill health than recovery.” In other words, when we are ill we should take time to rest rather than rushing back to work or school while still unwell. “I don’t think that enables us to get better,” says Cliff. ■

Technology

Google hails another step towards a truly useful quantum computer

Matthew Sparkes and Alex Wilkins

GOOGLE has demonstrated that its approach to quantum error correction – seen as an important element of developing useful quantum computers – is scalable, giving researchers at the company confidence that practical devices will be ready in the coming years.

The building blocks of a quantum computer are qubits, akin to the transistors in a classical computer chip. But today's qubits are susceptible to interference and errors that must be identified and corrected if we want to build quantum computers large enough to tackle real-world problems.

One popular approach to this is called surface code correction, in which many physical qubits work as one so-called logical qubit, essentially introducing redundancy. This is how much of the error correction in classical computers works, but in quantum computers it brings an added complication because each qubit exists in a superposition of 0 and 1 and any attempt to measure them directly destroys the data.

This means that adding more physical qubits to your logical qubit can actually be detrimental. "So far, when engineers tried to organise larger and larger ensembles of physical qubits into logical qubits to reach lower error rates, the opposite happened," says Hartmut Neven at Google.

Google demonstrated this when it first announced a working error correction scheme in 2021, which resulted in a net increase in errors. Now, the company has shown that logical qubits can be increased in size and that this scaling-up brings a reduction in the overall error rate. If that trend can be continued as quantum computers get bigger, then they will be capable of computation that would be impossible on even the most powerful classical computers. Neven says there is now "palpable confidence" among the team that Google will create a commercially useful quantum computer.

The team used the third generation of Google's Sycamore quantum processor, which has 53 qubits. Surface code logical qubits are typically a grid of qubits paired with another of the same size, with a single qubit reserved to measure the value of others. The company's experiment saw a move from 3 by 3 grids, involving 17 physical qubits, to 5 by 5 grids using 49 qubits, meaning almost the entire processor was acting as a single logical qubit. This increase brought a reduction in error rate from 3.028 per cent to 2.914 per cent (*Nature*, doi.org/grtkx6).

> "There is palpable confidence that a commercially useful device will be created"

Google's team concedes that the improvement is small, but says that, in theory, the scaling-up can be continued and paves the way for a fault-tolerant computer that can reliably carry out useful tasks. But moving to a 6 by 6 logical qubit – which would involve 71 physical qubits – will require a big step forward in hardware.

Fernando Gonzalez-Zalba at the University of Cambridge says it would have been good to see a larger improvement in the error rate, but that the research is moving in the right direction. "I don't think we are talking about years before we can see a scalable quantum error correction, I think they are pretty close." ▮

Climate change

Artificial islands could let Maldives adapt to rising seas

XINHUA/ALAMY

Hulhumalé, a new island in the Maldives built to withstand sea level rise

THINK of the Maldives and an image of an idyllic white-sand beach probably springs to mind. But the future of this nation of 1190 islands may be one of high-rise apartment blocks and skyscraper offices if it is to cope with rising sea levels.

"Sea level rise is inevitable," says Ali Shareef, a former climate change official in the Maldives government. "Even if Paris Agreement 1.5°C goals are met, the committed sea level rise over the multi-century period is higher than 1.5 metres, the average elevation of Maldives. Therefore, we need to find a solution to adapt to that rising sea level."

Shareef has worked with colleagues and researchers in the UK to explore how low-lying island nations like the Maldives could be saved by engineering raised islands to cope with higher sea levels.

Construction is already under way to build new islands with a higher elevation by pumping sand from the sea floor. The entire population of the Maldives – more than half a million people – could live on just two heavily built-up islands raised in this way, the researchers conclude (*Environmental Research: Climate*, doi.org/jxts).

One is already taking shape in the form of Hulhumalé, built to be 2 metres above sea level. It is home to more than 90,000 people so far. The study proposes that a second island would need to be created that is up to 6 metres above current sea level, to prepare for the possibility of much greater sea level rise.

Nearby, privately managed tourist islands – which would periodically be rebuilt to cope with higher sea levels – could still offer beach retreats for paying visitors.

"I think the key point is that island raising can offer a long-term solution," says Robert Nicholls at the University of East Anglia in Norwich, UK, who was part of the research team. ▮

Madeleine Cuff

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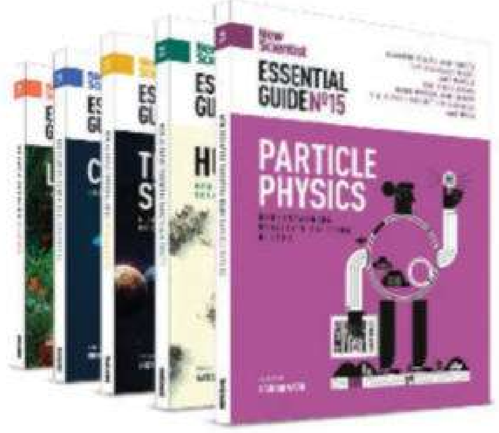

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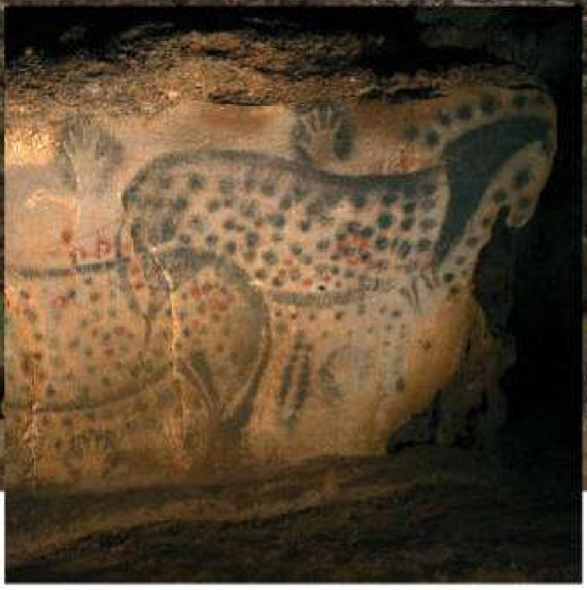

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Neanderthal origins: Southern France

Step back in time on a journey to the key Neanderthal and Upper Palaeolithic sites of southern France between Bordeaux and Nice with Palaeolithic archaeologist and author Dr Rebecca Wragg Sykes. See some of the oldest evidence left by archaic humans including stone tools, art objects, cave paintings and skeletons that have changed the way we think about Neanderthals. Visit renowned archaeological sites and gain a deep understanding into the life and development of the Neanderthals, all while discovering the beautiful medieval towns and stunning countryside of the south of France.

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Space

JWST spots unusually large and young galaxies

Leah Crane and Alex Wilkins

MANY galaxies in the early universe seem to be far more massive than expected. Researchers using the James Webb Space Telescope (JWST) spotted galaxies with masses up to 100 billion times that of the sun that must have formed faster than current models can explain.

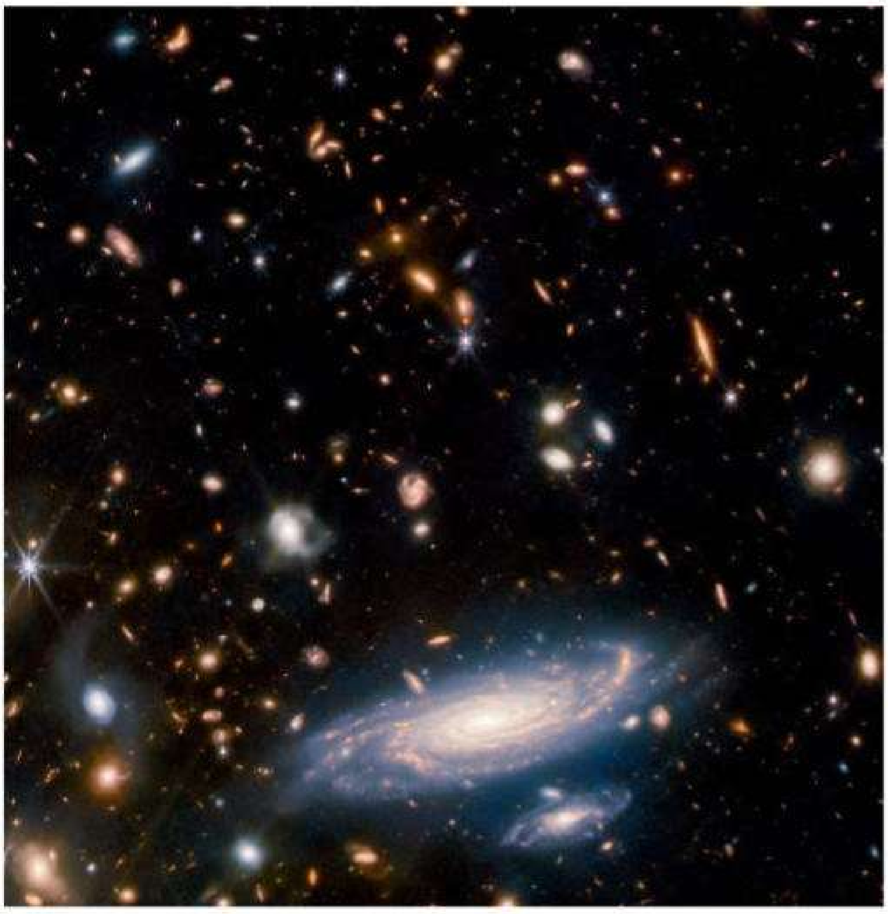
Ivo Labbé at Swinburne University of Technology in Australia and his colleagues measured the distances to six massive galaxies using a phenomenon called redshift. Objects that are further from Earth are moving away from us more quickly, which causes them to appear more red than nearby objects. They found that these galaxies were all around 30 billion light years away, meaning that they formed within 700 million years of the big bang.

"I would have guessed that galaxies like this would not exist this early in the universe," says Pieter van Dokkum at Yale University in Connecticut, who was part of the research team. That is because the galaxies all had masses at least 10 billion times that of the sun, with one weighing in at 100 billion solar masses.

30bn

Distance away that the galaxies are in light years

From models of galactic evolution, we would expect galaxies as young as these to be relatively low mass, without many stars at all, and then to grow over time until they became more like our own Milky Way galaxy, which has a mass of about 1.5 trillion solar masses (*Nature*, doi.org/jxpk).



ESA/WEBB, NASA & CSA, A. MARTEL

Galaxies spotted by the James Webb Space Telescope

While these young galaxies are massive, they are also surprisingly compact. "What could be going on is that the centres of galaxies form very early, earlier than we thought, then the rest of the galaxy builds up around them," says van Dokkum. "I suspect that we're looking at not-finished products, but beginnings that happened very quickly."

The exact mechanism behind this "fast-track" galaxy formation – or galactic core formation, as it may be – remains to be seen.

"If all of this holds up with further investigation, then we are looking at having to rethink about some of the early history of galaxy formation," says Andrew Pontzen at University College London.

JWST has also spotted several other galaxies that seem to have formed well before expected, but they also need confirmation before we can say for sure that galaxies formed earlier in the universe than we thought. Follow-ups will consist of observations and analysis of the galaxies' light spectra with JWST.

If these findings do hold up, it may be a problem for our understanding of the universe more generally, not just galaxy formation.

"It was pointed out to us after we submitted the paper that there wasn't actually enough gas in the universe at that point to form [as many massive galaxies as this study suggests] – and that was a bit of a shocker," says Labbé. "If you form these monsters, and they contain more stars than the available gas in the universe, that's a bit of a problem." ▮

Health

HIIT seems safe and boosts fitness after a heart attack

Alice Klein

AFTER a cardiac event, people are often advised to improve their heart health via gentle exercise. Now, research suggests that high-intensity interval training (HIIT) is also safe after a heart attack or other cardiac event and may improve fitness faster than moderate-intensity exercise.

Gordon McGregor at University Hospitals Coventry and Warwickshire NHS Trust in the UK and his colleagues looked at 382 adults, with an average age of 59, who had been referred to cardiac rehabilitation centres with coronary heart disease or after a recent heart attack or heart-related procedure. They had shown no signs of their condition worsening for at least two weeks.

Some were randomly chosen to do moderate exercise: 20 to 40 minutes of continuous activity on an exercise machine at 60 to 80 per cent of their maximum aerobic capacity. The rest did HIIT, vigorous bursts of exercise interspersed with short rest periods. This involved exercising for 1 minute on a stationary bike at more than 85 per cent of their maximum capacity, then 1 minute's rest, repeated 10 times.

The HIIT group showed greater improvements in cardiorespiratory fitness, measured via peak oxygen uptake during exercise (*European Journal of Preventive Cardiology*, doi.org/jx3h). This may reduce the risk of premature death by around 15 per cent, says McGregor.

One participant developed chest pain during a HIIT session and was diagnosed with an irregular heart rhythm, but it wasn't life threatening and was probably unrelated to the training, says McGregor.

The Association of Chartered Physiotherapists in Cardiovascular Rehabilitation, which writes the UK's cardiac rehab guidelines, is reviewing this trial and will release updated guidelines this year. ▮

Health

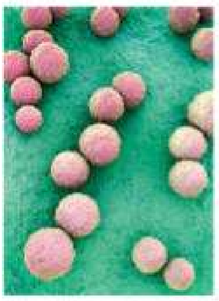
Immune response links rheumatoid arthritis flare-ups with gum disease

Clare Wilson

BACTERIA that reside in our mouth can enter the blood and trigger hallmarks of immune activity involved in rheumatoid arthritis, researchers have found, bolstering the idea that gum disease may contribute to the painful joint condition.

The study is among the first to show that the same antibodies that target the joints in rheumatoid arthritis also attack bacteria that live on the gums, and strengthens the advice that people with the condition should maintain good dental hygiene, says Dana Orange at Rockefeller University in New York.

Rheumatoid arthritis is an autoimmune condition, which means the immune system attacks the body's tissues. Past research suggests that people with the condition are more likely to have gum disease, when the gums are inflamed and sometimes bleed, but it is unclear why.



***Streptococcus* bacteria can cause gum disease**

KATERYNA KON/SCIENCE PHOTO LIBRARY/ALAMY

Now, Orange and her colleagues have monitored five people with rheumatoid arthritis, two of whom also had gum disease, by asking them to provide weekly blood samples for up to four years. These samples were tested for bacterial genetic material, as well as several markers of immune system activity.

Only the participants with gum disease had traces of genes from mouth bacteria, such as *Streptococcus* species, in their blood, usually seen every few weeks (*Science Translational Medicine*, doi.org/jxpp).

This is probably caused by episodes of bleeding gums, says Orange. "As the blood is coming out, the bacteria are going in."

The researchers also sometimes found traces of bacteria that normally live on the skin in the blood samples, but these weren't accompanied by immune activity. This suggests the skin bacteria contaminated the sample while it was being drawn from a participant, says Orange.

A second part of the study analysed one-off blood samples from 73 people, about half of whom had rheumatoid arthritis. One blood test for rheumatoid arthritis looks for antibodies that target a group of proteins with a chemical modification called citrullination. This alteration can happen to any protein, but certain citrullinated proteins are found at high levels in the joints of people with rheumatoid arthritis.

The team found that antibodies against citrullinated proteins from those with rheumatoid arthritis also worked against citrullinated proteins made by the mouth bacteria that enter the blood. This suggests that mouth bacteria reach the blood, triggering immune cells to make antibodies against citrullinated proteins, causing an arthritis flare-up, says Orange.

While the study was small, Paul Emery at the University of Leeds, UK, says sampling blood weekly adds to the validity of its results.

"People with rheumatoid arthritis should maintain good dental hygiene practices"

"It's the first one that shows a correlation between [markers of] rheumatoid arthritis flares and bacteria in the blood," he says.

Immune activity caused by gum disease has been linked with a number of medical issues, from Alzheimer's disease to heart attacks. In Alzheimer's, the mouth bacterium *Porphyromonas gingivalis* has been implicated in the condition. ▮

Animals

Elephants may remember relatives by smell for 12 years

THE memory of elephants is the stuff of lore, and now it seems they can recall the smell of a relative even after a decade apart.

When Franziska Hörner at the University of Wuppertal in Germany and her colleagues heard about planned reunions between two mother-daughter pairs at zoos in Germany, they took advantage of the chance to test the elephants' memories. One pair had been separated for two years, while the other had spent 12 years apart.

Hörner collected faecal samples from these African elephants (*Loxodonta africana*) and others at German zoos, hauling the stinking 10-to-15-kilogram stools around in her tiny car.

Her team presented these samples one at a time to the four elephants in advance of their reunions with family members. When they encountered heaps of faeces from unrelated elephants, either those in the same zoo or unfamiliar animals, they sniffed the dung piles and walked away.

But when presented with a sample from the mother or daughter they were due to be reunited with, the female elephants repeatedly sniffed the samples and showed a variety of reactions, from rumbling sounds to flapping their ears (*Animals*, doi.org/jxtt).

Two elephants reunited at Zoo Halle in Germany after a long separation

DENNIS MULLER/ZOO HALLE

Such reactions may be linked to positive emotions, the researchers say. "That was amazing and really intense," says Hörner. "We were sure they do remember, and they know exactly what they are smelling there."

The sample size was small, but it would be cruel to do similar tests on elephants that weren't being reunited, says Hörner.

"I am not surprised that elephants have memories, especially in social contexts, that last a long time," says Joshua Plotnik at Hunter College in New York, who wasn't involved with the work. Elephants live in groups that split up and come back together over long periods of time.

But Plotnik says the experiment may not be a true test of memory. There may be scent cues common to all kin that can trigger recognition not linked to memory, he says, and presenting the elephants with a slew of other smells would help make sense of their responses. ▮

Carolyn Wilke

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Archaeology

Some of the first humans in Europe used bows and arrows

Michael Le Page

BOWS and arrows were first used in Europe much earlier than we previously thought. More than 100 arrowheads have been found in a rock shelter briefly used by a group of modern humans 54,000 years ago in an early foray into Neanderthal territory.

"It's incredible how many we have," says Laure Metz at Aix-Marseille University, France.

Metz is part of a team that has been excavating a rock shelter called Grotte Mandrin in southern France. This shelter was used first by Neanderthals more than 80,000 years ago, and then by modern humans from about 45,000 years ago – around the time that modern humans displaced Neanderthals all across Europe.

But, last year, the team reported that, for a 40-year period around 54,000 years ago, Grotte Mandrin was used as a hunting camp by a small group of modern humans. The clinching evidence came from a baby tooth that isn't from a Neanderthal.

In the layers of earth from this time, Metz and her colleagues have now reported finding more than a thousand small stone points about 1 or 2 centimetres in length. Of these, around 100 have been identified as broken or complete arrowheads because they have one or more signs of impact damage resembling those seen when the team used newly made stone points as arrowheads. The others may be arrowheads too, but the researchers are unsure (*Science Advances*, doi.org/grtjdj).

LUDOVIC SLIMAK

Reproductions of ancient arrows used by early humans

"The tips from Mandrin could hardly have been used in any other way than to tip arrows," says Marlize Lombard at the University of Johannesburg in South Africa, who wasn't involved in the study.

Most of the Mandrin arrowheads are broken. Some are arrowhead tips that broke off inside animals and were brought back to camp inside butchered meat, says Metz. Many of these show signs of charring from fires.

The parts that remained attached to the shaft have also been found. Because of the work involved in making arrow shafts, when an arrowhead broke, hunters would have brought the arrow back to camp and replaced the arrowhead, discarding the broken one, says Metz.

Before now, the earliest unambiguous evidence for bows and arrows in Europe came from finds in Stellmoor, Germany, dating to around 10,000 years ago, she says. However, it was considered likely that the modern humans who displaced Neanderthals around 45,000 years ago had bows and arrows.

Bows and arrows were first developed in Africa at least 70,000 years ago, and Lombard and others have found stone and bone arrowheads at several sites in southern Africa dating back as far as this. The modern humans who moved out of Africa may have spread the technology around the world. ▮

LAURE METZ AND LUDOVIC SLIMAK

Arrowheads found at Grotte Mandrin in southern France

Health

Fasting for a day may weaken the immune system

Grace Wade

FASTING has been suggested as a way to manage chronic conditions like cancer or obesity – but mouse studies show that prolonged fasts may impair the immune system.

Filip Swirski at the Icahn School of Medicine at Mount Sinai in New York and his colleagues studied five mice that had no access to food for 24 hours. Blood tests comparing these mice with those on a regular diet showed that, on average, they had less than 10 per cent of the number of monocytes – a type of white blood cell that helps fight infections and recruits other immune cells to treat injury.

These cells are critical foot soldiers of the immune system, says Swirski. The decrease was due to monocytes retreating from the blood to the bone marrow, where they essentially hibernated and survived longer than they would otherwise, he says. When the fasting mice were given food again, monocytes rushed back into their bloodstream. Compared with mice that continued to fast or those that never fasted, these mice had nearly four times as many monocytes in their blood, on average.

The researchers then injected 45 mice with a strain of bacteria that infects the lungs. Twenty-three of the mice fasted for 24 hours before the injection, and were then allowed to eat. After 72 hours, nearly 90 per cent of the fasting mice had died, compared with about 60 per cent of the mice that never fasted. The mice on restricted diets also had greater levels of inflammation, suggesting that long periods of fasting impair immune responses (*Immunity*, doi.org/grtpk4).

However, Satchidananda Panda at the Salk Institute for Biological Studies in California says that most fasting regimens for humans don't last 24 hours. His own research has shown that a 15-hour fast improves immunity in mice. ▮

Medicine

New drug may ease endometriosis

AN ANTIBODY that reduces inflammation partly reverses endometriosis when given as a monthly injection. After successful tests in monkeys, it is now being trialled in people.

Endometriosis occurs when tissue from the endometrium – the lining of the uterus – grows in other parts of the body, usually in the pelvis. It affects around 1 in 10 women of a reproductive age and can cause bad pain and infertility.

Ayako Nishimoto-Kakiuchi at Chugai Pharmaceutical in Japan and her team developed an antibody called AMY109 that inhibits IL-8, an inflammatory protein produced in endometriosis tissue. Endometriosis lesions in monkeys given AMY109 for six months halved in size (*Science Translational Medicine*, doi.org/grtqfq). **Alice Klein**

LUKAS JONAITIS/ALAMY

Technology

Turn kombucha mat into a circuit board

A BYPRODUCT of making the drink kombucha can be used to create flexible electronic circuits, possibly for wearable technology.

More than 60 types of bacteria and yeast are involved in brewing kombucha from sugared tea and these form a mat of cells on top of the drink that is removed.

Andrew Adamatzky at the University of the West of England, Bristol, and his colleagues have now found that when dried, the mat of cells can be used to create flexible circuit boards that still work when bent and stretched (arxiv.org/abs/2302.03984).

The researchers say that kombucha circuits are lighter, less expensive and more flexible than conventional electronic systems and could be used in a diverse range of applications, including wearable devices, such as heart rate monitors. **Matthew Sparkes**

Animal behaviour

How forest-killing beetle sniffs out its tree victims

BARK beetles may use receptors in their antennae to detect and feast on fungus-infected trees.

The Eurasian spruce bark beetle (*Ips typographus*) burrows into the bark of Norway spruce (*Picea abies*) where it feeds and reproduces. In doing so, the pine-nut-sized insects can kill large areas of forest.

Researchers already knew that bark beetles preferred to attack trees weakened by certain fungi, potentially because fungi provide the insects with protective benefits from bothersome microbes and parasites, and could act as a food.

But how the beetles were sensing their infected hosts wasn't known. Jonathan Gershenzon at the Max Planck Institute for Chemical Ecology in Germany and Dineshkumar Kandasamy at Lund University in Sweden investigated this by identifying compounds released by spruce trees infected with *Grosmannia penicillata*, a fungus almost always found in trees that succumbed to bark beetle. They found the fungus created two key chemicals: camphor and thujanol.

Next, the researchers examined the beetles' anatomy and found scent-detecting neurons in their antennae that can detect camphor and thujanol. When they gave the insects their choice of healthy or *G. penicillata*-infected spruce bark in the lab, all of the beetles were more attracted to the fungus-damaged wood. The presence of the fungus-produced compounds not only attracted the beetles, but also spurred them to tunnel into the bark.

When bark was infected with a fungus not beneficial to the beetle, which also produced different chemicals, the insects weren't attracted to the wood (*Plos One*, doi.org/grtdmj). **Corryn Wetzel**

Really brief

ARMANDO AZUA-BUSTOS

Mars life may evade current detectors

Instruments sent to Mars may not be able to detect life there, should it exist. Comparable devices tested in a part of the Atacama desert in Chile (pictured) that is geologically like Mars detected barely any microbial material. But newer versions found DNA from 20 or so species (*Nature Communications*, doi.org/jxt3).

Peregrines changed diet in lockdown

London's peregrine falcons ate more starlings and parakeets than normal and fewer pigeons during the UK's first covid-19 lockdown in 2020. It is thought many pigeons relocated as London's visitors, and associated food debris, dried up (*People and Nature*, doi.org/jx3m).

Throat mic detects silent speech

A tiny graphene patch worn outside the throat can detect your speech and broadcast it even when you mouth words silently. It could aid communication by firefighters or pilots in noisy environments or help people with speech difficulties (*Nature Machine Intelligence*, doi.org/jxtr).

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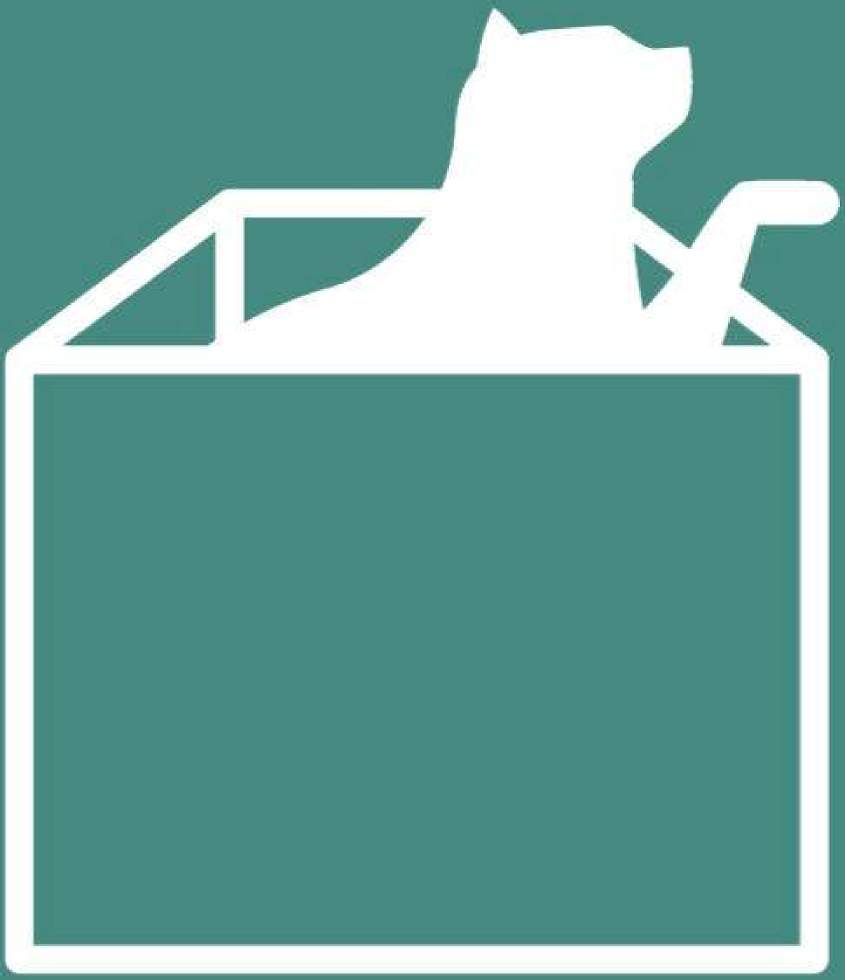

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Comment

Drying up

Human ingenuity can't engineer a solution to a water crisis that has reduced the Colorado river to a trickle, argues **Natalie Koch**

MICHELLE D'URBANO

SEVEN states in the Southwest US are legally allowed to take water from the Colorado river: Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming. But with the once-mighty river now running at historic lows, the states were given a federal deadline to voluntarily agree to dramatic cuts in their use. On 31 January, they missed it. Meanwhile, the low river flow has already slashed the power output of the iconic Hoover dam – once able to produce 2080 megawatts of hydropower per year, its generation has been cut in half as of June 2022.

Overuse and climate change have reduced the Colorado river to a trickle, while a decades-long population boom in the desert Southwest has only increased demand for its water. The region's rapid growth has never been sustainable, but recent restrictions in cities like Las Vegas and Phoenix have succeeded in curbing some of the water waste that could make the current crisis even worse. And since Arizona's new water-conscious governor Katie Hobbs took office in January, she has revealed that the previous administration failed to enforce the state's requirement that new housing developments guarantee water provision for 100 years.

But Hobbs and water experts across the Colorado river basin know that unchecked development is only the tip of the iceberg – and that agriculture is the real problem sector, accounting for the vast majority of use of the Colorado river basin's water. Water laws in the west of the US are as complex as they are arcane. But, for more than a century, they have facilitated the rise of unsustainable commercial agriculture across the region.

Ever since Arizona was first colonised, hubristic political leaders and entrepreneurs have profited from selling the idea that human ingenuity can engineer a solution to water shortfalls. This view is currently being sold to Arizona by an Israeli company, IDE Technologies, that promises to build a $5.5 billion desalination plant in Puerto Peñasco, Mexico – with water exported to Arizona via a 320-kilometre pipeline. This is ironic because the University of Arizona first started researching water desalination technologies in Puerto Peñasco in the early 1960s.

What the Arizona team found was that large-scale desalination operations demand extraordinary amounts of energy. In the 1960s, the energy cost of desalinating seawater was unrealistic for the US. As I show in my book, *Arid Empire*, Arizona researchers started promoting joint desalination-greenhouse projects in the Arabian peninsula. There, diesel generators, then crude oil and later natural gas, could be used to power desalination plants.

Today, every city in the Arabian peninsula depends on vast desalination operations. But even there, where governments have practically free oil and gas, the cost of powering desalination facilities is far too high for them to support large-scale agriculture. And where commercial farming has developed, this has lasted only so long as the groundwater reserves. In Saudi Arabia, that time has passed and the kingdom now sits atop dry aquifers.

This is precisely why the desert Southwest can't just engineer itself out of its water crisis. If desalination can't support commercial agriculture where the plants run on state-owned fossil fuels, it certainly can't be supported in a region without cheap energy access. Meanwhile, Saudi investors have acquired land in Arizona to take advantage of the state's lax water laws. Though this caused an uproar last year, the opposition of Arizona's farmers to any groundwater regulation all but guarantees the state's aquifers will run dry too.

Making the desert bloom through commercial farming has always been a romantic idea. But it has also always been a mirage. ■

Natalie Koch is a professor at Syracuse University and author of *Arid Empire: The entangled fates of Arizona and Arabia*

Field notes from space-time

The importance of uncertainty

Quantum mechanics had a disordered beginning and is still developing today. Science is rarely a done deal, says **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading

I'm teaching this semester from Arjun Berera and Luigi Del Debbio's new textbook Quantum Mechanics.

What I'm watching

I'm enjoying the new Sylvester Stallone series Tulsa King.

What I'm working on

Recently my team has been stuck on a sticky calculation where the computer and pen/paper disagree!

This column appears monthly. Up next week: Graham Lawton

ONE of the challenges of teaching is picking a textbook because finding one that is reasonably priced and at the right level for my students is hard. And the more advanced a topic is, the more likely it is to include areas that are the subject of current research, where thinking is changing in real time.

Textbooks are designed to teach a subject as if it is understood, to have an authority that gives students confidence in the contents. This method of learning, while useful for helping people get a sense of the ideas at hand, can also give the false impression that a subject was conceived in an orderly fashion and has been static pretty much since then.

Quantum mechanics, the technical term for what is usually known as quantum physics, is an example of a subject that had a disordered evolution in its early stages, and that is still developing. Ideas that we traditionally associate with quantum mechanics are considered by at least some researchers to be less central to it these days.

For example, I recently suggested to a friend that maybe I should have taught my spring 2023 PhD quantum mechanics course using Paul Dirac's 1930 book *The Principles of Quantum Mechanics*. In it, he introduces a mathematical framing of quantum mechanics that presents the calculational basics of the field. It is taught to nearly every professional physicist at some point.

My friend responded: "Nah, he focuses on old-school concepts such as uncertainty." I had to giggle when I read this because the uncertainty principle is considered a hallmark quantum concept: the idea that we can't simultaneously know both the precise position and velocity of a particle is one of the quantum world's oddities.

I still think there is value in understanding how people thought at the time quantum mechanics took shape. One of my favourite stories from its early period is about the Stern-Gerlach experiment. In this, Otto Stern, a theoretical physicist, and Walther Gerlach, an experimentalist, teamed up in 1922 to try to prove that Niels Bohr's ideas about the structure of the atom were wrong.

Bohr had, about a decade before, been trying to explain why atoms are stable. Consider hydrogen, with a nucleus and a single electron. In the scenario where we think of the nucleus as the sun and the electron like a planet in its orbit, there is a problem: electromagnetism teaches us that a charged particle like the electron will lose energy when it is accelerating, and constantly changing direction in orbit is a form of acceleration. The energy loss would cause the orbit to decay, meaning the electron should crash into the nucleus, destabilising the atom. Yet, hydrogen and many more massive atoms are stable. What gives?

> **"I think there is value in understanding how people thought at the time that quantum mechanics took shape"**

Bohr suggested that maybe the electron could only be in discrete orbits at set distances. This spatial quantisation had big implications for other properties, such as how magnetic forces would affect the motion of an atom.

Stern hated this model and was determined to show it was wrong. He and Gerlach did an experiment which sent a beam of silver atoms through a magnetic field. The goal was to show that the atoms would land on a target with a continuous vertical distribution, reflecting a non-quantised atom. To Stern's chagrin, they found that all of the atoms landed in one of two locations – one up and one down – and not in between. There was no possible explanation for this result from classical physics. It is a fundamentally quantum result. They sent Bohr a postcard telling him that he was right.

Ironically, Bohr's model was wrong. It wasn't until the mid-1920s that people realised what Stern and Gerlach had actually shown: electrons have a quantum internal rotation that we now call "spin". This can take one of two values, but nothing in between. This property and how it interacts with magnetic fields meant that in the Stern-Gerlach experiment the atoms all either deflected a set amount up or down based on their spin value, but couldn't deflect to points in between as intermediate spin values are impossible. Today, Bohr's atom is still taught as it is considered a good approximation, but it is also known as a core piece of "old quantum theory" which we now know isn't right.

Just a few years after the spin connection was made, Dirac wrote his book pulling many pieces of quantum mechanics together into a unified framework, one we are still teaching students today. It is so elegant, it is easy to forget that isn't how it started.

I opened my course this semester by teaching the Stern-Gerlach experiment because it is instructive in a few ways. Stern, who was Jewish, had to leave Europe. Gerlach became head of nuclear research in Nazi Germany. Sometimes scientists are simultaneously right and wrong. ▮

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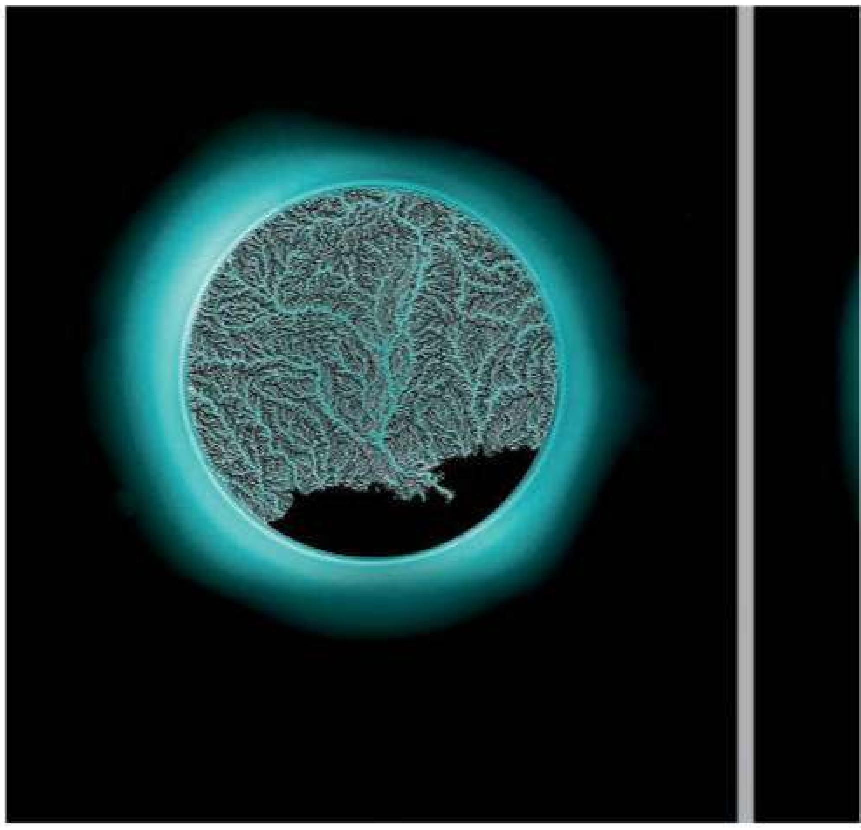

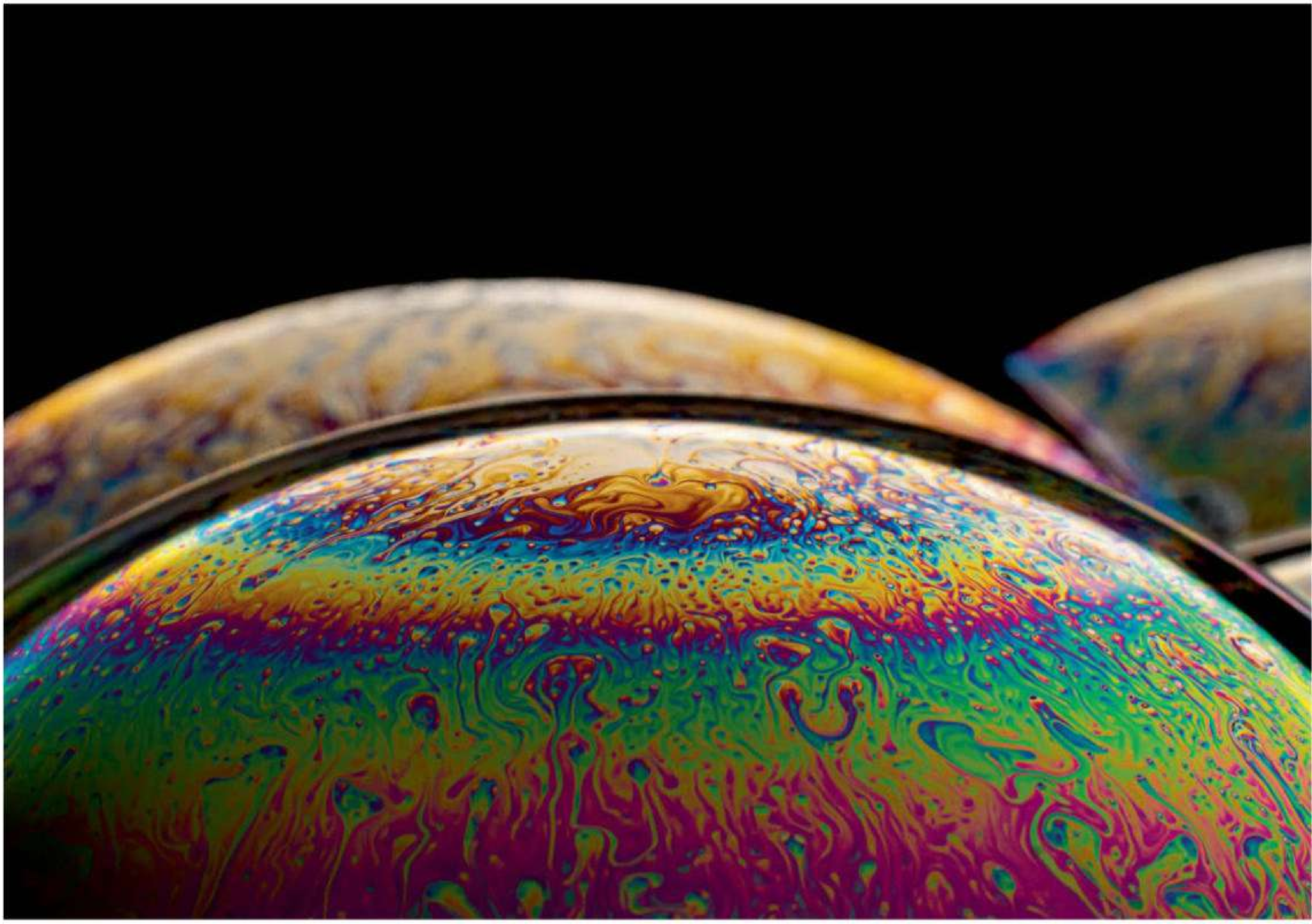

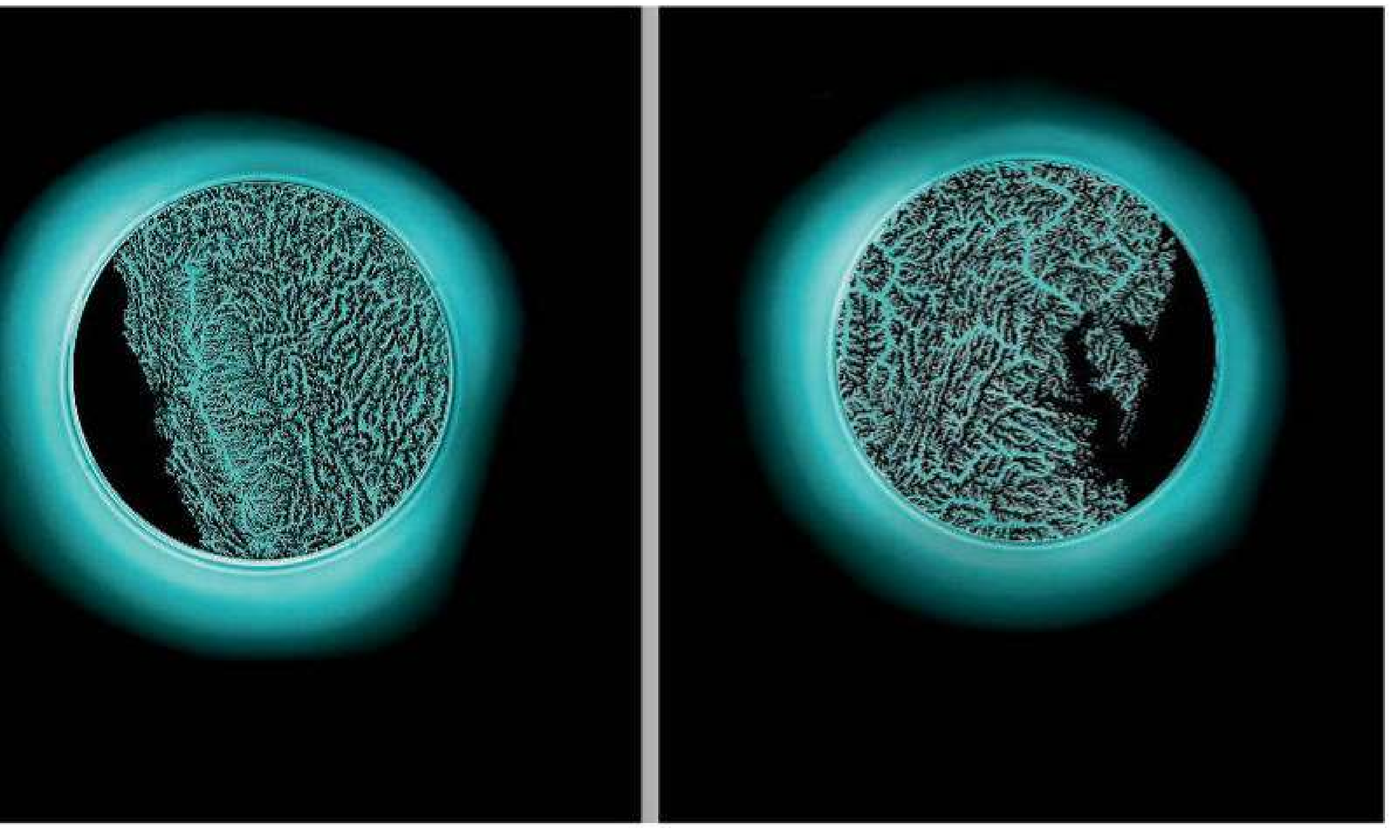

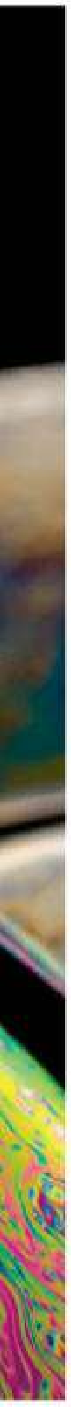

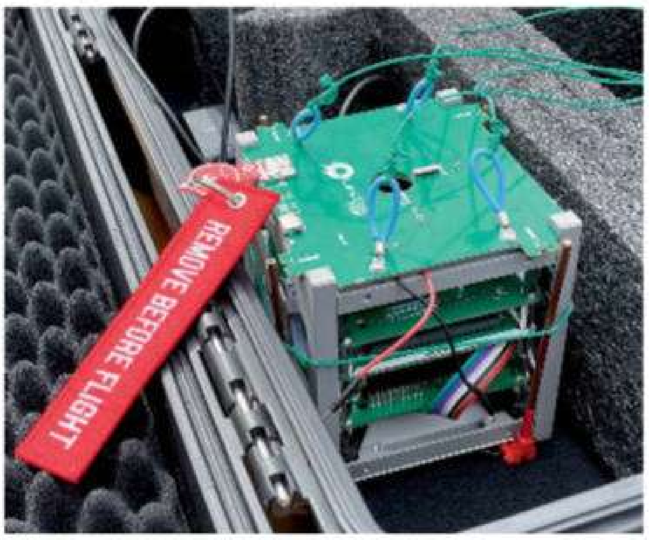

Top shots

Royal Photographic Society

FEMALE scientists are still a minority, making up a third of all researchers. In celebration and support of the UN's International Day of Women and Girls in Science, the UK-based Royal Photographic Society held its first Woman Science Photographer of the Year competition.

"Representation helps to invite the next generation to follow their curiosity and get involved in the fields of science and art," said Margaret LeJeune, who took the adult category's top prize for her image titled *Watershed Triptych* (top right). It shows maps of the three largest watersheds in the US, lit by bioluminescent marine algae called dinoflagellates. Though their glow looks dazzling, the toxins some of them release can pose a threat to ocean life.

The Young Woman Science Photographer award, open to under-18s, went to Kelly Zhang for *The Beauty of Soap Bubbles* (bottom left) – a trippy shot of the iridescent surfaces of these delicate spheres. Finalists also included Lianna Nixon for *Leap of Science* (top left), which provides a snapshot of the recent MOSAiC Expedition that probed how the Arctic will be affected by climate change. Here, researchers are searching for a spot to measure the surface reflectivity of sea ice.

Some shortlisted photos are shown in the trio of images at bottom right (clockwise from top): a paper and engine oil structure transformed by the growth of pink oyster mushrooms, by Jindra Jehu; a nanosatellite launched in 2022 to analyse air pollution, by Lina Yeleuova, runner-up in the under-18 category; the skin of a corn snake under UV light, by Irina Petrova Adamatzky. ■

Gege Li

Editor's pick

True value of clean rivers is far bigger than we think

Leader, 18 February

From Paul Whiteley, Bittaford, Devon, UK

You say that £870 million a year is the supposed beneficial impact on the UK's health thanks to rivers and lakes encouraging physical activity and relaxation. I wonder if there is another, hidden cost that should be added in due to polluted waters.

Back in 1995, I swam in a river downstream of a treatment works in Devon that pumps raw sewage into the water. The resultant ear infection caused tinnitus and hearing loss. I received many years of treatment from the National Health Service that has probably cost it tens of thousands of pounds.

Lunar dust sunshield may do more harm than good

18 February, p 18

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

Your story on using moon dust to create a sunshield for Earth implies that the 1 million tonnes of dust needed would have to be replaced at the rate of 200,000 tonnes a day. While you mention the possible use of a railgun to propel the dust into space, there would need to be infrastructure for other aspects of this.

Presumably, actual dust sources would soon be exhausted, and so machinery to mine and crush 200,000 tonnes of moon rock a day would be needed. All of this must be built and transported to the moon, probably within a few decades. Has anyone calculated the carbon footprint of doing this?

Let's look for evidence of interstellar shift on Earth

18 February, p 38

From John McIntosh, Birkenhead, Merseyside, UK

"Into the void" suggests we may risk an increase in cosmic rays as our planet passes into a new area of interstellar space in about 2000 years. We entered the area we are currently in around 60,000 years ago. I suggest calculating when previous transitions occurred to see if they tally with events in Earth's history.

Old tech may be just what the climate crisis needs

18 February, p 27

From Eric Kvaalen, Les Essarts-le-Roi, France

I was glad to see Mark Jacobson rectifying some of the overblown optimism around carbon capture and storage, direct air capture, "blue hydrogen" and so on.

He didn't mention electrification of vehicles, but there are significant problems with this as well, on a global scale. I think these downsides should be weighed against the problems with biofuels, which are the most convenient alternative to petrol and diesel fuel and are really needed for aviation.

Also, there is another way to remove carbon dioxide from the air that doesn't need new technology, just incentives and organisation – namely, storing biomass so that it doesn't rot and return carbon to the atmosphere.

From Gethin Bermingham, Lancaster, UK

Jacobson makes the point that we will only achieve our climate goals on the short timescales necessary if we use existing technologies. I and most people would agree. Unfortunately, he then includes a yet-to-be developed technology as one of the solutions. Storage for renewables, despite what he says, is nowhere near ready to help support solar and wind to any meaningful extent. He also says that uranium will run out. It won't, at least not during the period that would be needed to bridge the gap to future technologies.

Remember, kimchi isn't the only fermented food

4 February, p 41

From Avril Arthur-Goettig, Munich, Germany

We hear more and more about fermented foods and how good they are for our microbiome and hence our immune system. But it is frustrating to always hear kimchi given as the example.

What about our centuries-old European tradition of fermenting cabbage or root vegetables to provide nutrients and, above all, vitamin C over the winter. Often served with spicy sausage or as a soup, such ferments are called *choucroute* in French and sauerkraut in German.

Let's turn the wood wide web on its head

18 February, p 10

From Paul Rendell, Tywyn, Gwynedd, UK

You report doubts about the "wood wide web", in which trees communicate and share resources via buried fungi. I think it is more likely that the fungi are in charge, actively encouraging certain types of tree to grow in certain spots. The fungi could favour mixed woodland species and discourage monocultures. Could a mature forest be the garden of fungi?

On the hope that climate extremes are unlikely

14 January, p 28

From Robert Antonucci, Santa Barbara, California, US

Is a 4°C temperature rise by 2100 ruled out? Graham Lawton assures us that the current models say so. However, I wonder if there is an assumption that climate feedbacks will be constrained. The models don't include release of methane from permafrost at the observed and rapidly rising level. In the past few years, anthropogenic methane emissions haven't been rising a lot, but the level of this greenhouse gas in the atmosphere has.

Worriers, resolve to go fretless for Lent!

11 February, p 42

From Peter Slessenger, Reading, Berkshire, UK

Kayt Sukel reports on people scheduling set periods when they are allowed to worry as a way of managing and reducing paranoia. I suggested another approach to someone, that they give up worrying for Lent, as they were always fretting about something. They felt so much better that they did this every year.

All hail energy saving, now let's look at water

11 February, p 36

From Maria Felice, Bristol, UK

I thoroughly enjoyed reading your feature on the 2000-watt energy-saving challenge.

We now need something similar for water consumption. There are few tools to track usage and not that much talk about it. Shouldn't we give water use the attention it deserves, or, like energy, are we going to leave it until it is (almost) too late?

Floating eyes in the sky are really nothing new at all

11 February, p 9

From Steve Johns, Axedale, Victoria, Australia

I find it amazing that it has taken China and the US until now to think of spying on each other using flying objects. I suggest the outrage may be manufactured for immediate political ends. ▮

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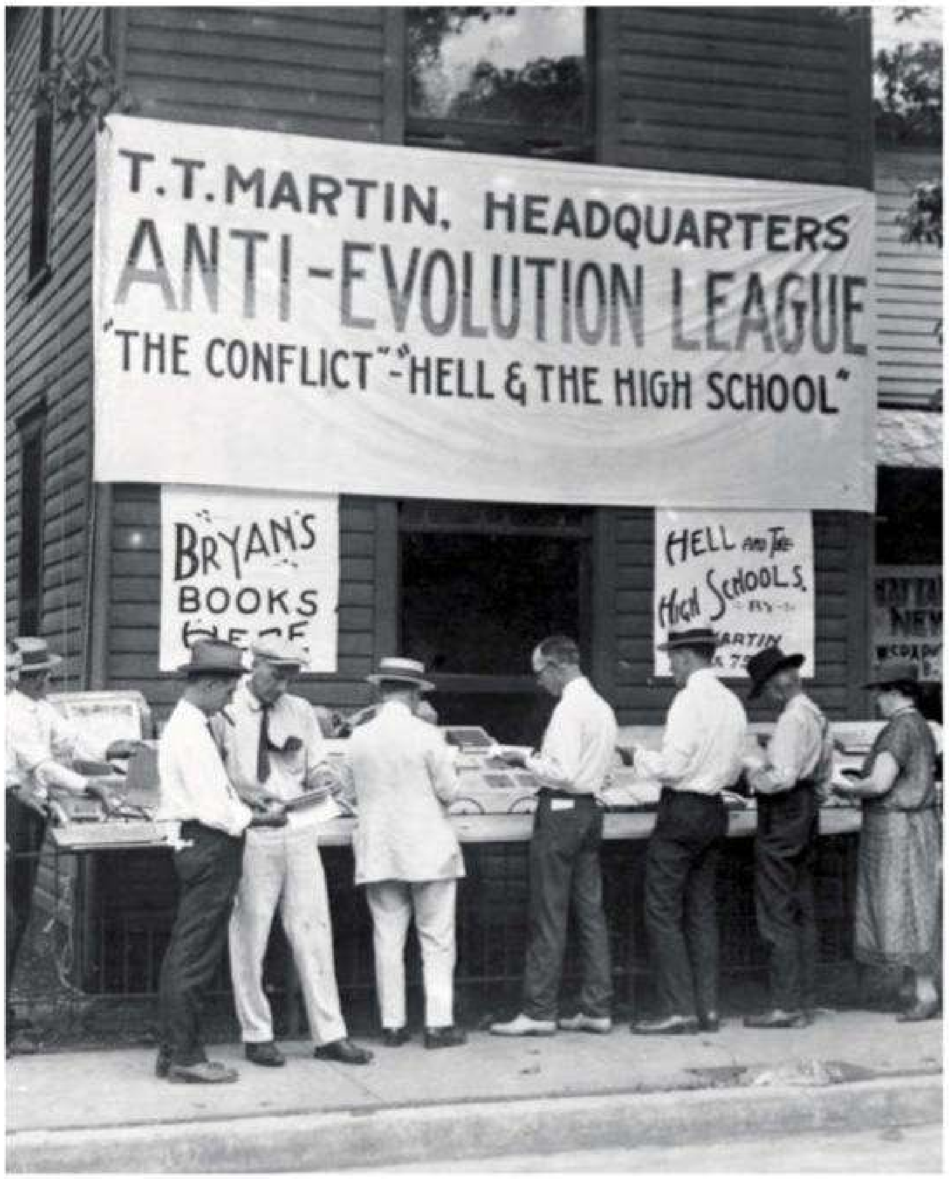
Reason and belief

Some argue that science and religion have always been separate and at war, but an eye-opening book reveals intertwined histories, finds **Joshua Howgego**

Book
Magisteria
Nicholas Spencer
Oneworld Publications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Anti-evolution books on sale in Dayton, Tennessee, in 1925

SCIENCE and religion are in opposition from their foundations upwards, right? One is built on reason and evidence, the other on belief.

Well, I have a confession to make: I don't buy it. I am an evangelical Christian and a *New Scientist* editor. Some might say I am the definition of a square peg in a round hole – but there it is.

I say all this by way of explaining why I was excited to get hold of Nicholas Spencer's new book *Magisteria: The entangled histories of science and religion*. I am already a fan of Spencer, who is a senior fellow at the Christian think tank Theos. I particularly enjoy the thoughtful, erudite podcast he hosts, *Reading Our Times*, which looks at the books and ideas shaping culture today.

In his own book, Spencer does what his subtitle promises – he recounts the entangled histories of science and religion and shows how there is so much myth and misunderstanding around how the two interact.

The book takes its title from palaeontologist Stephen Jay Gould's description of science and religion as "non-overlapping magisteria". In other words, they are distinct fields of endeavour that needn't – perhaps shouldn't – interact. Spencer wants to show us it isn't as simple as that. It isn't true to say that science and religion have been at war forever or that they have always been separate.

To his credit, he goes beyond merely saying "it's complicated". At the start of his book, Spencer identifies two crunch points where science and religion have repeatedly conflicted. These, he argues, are questions around "the nature and status of the human" and "who has the right to pronounce on nature, the cosmos and reality?". Overall, the book isn't an essay ramming this down your throat. It reads more like a traditional history, and Spencer's argument about these two crunch points comes across quite subtly.

Magisteria begins in the year AD 415 and examines the emergence of proto-science in the classical Christian, Jewish and Islamic worlds. It also covers the Enlightenment, Galileo, Darwinism, the development of quantum theory, right up to the recent development of machine learning. At 468 pages, it is quite a hefty book and there is plenty of detail here. But the depth of Spencer's scholarship shines through in every sentence. It isn't a short or simple story, but it is a surprisingly breezy one.

> **"Spencer's objective is to show how quantum theory didn't cause the same brouhaha as evolutionary theory"**

For me, Spencer's crunch points between science and religion really come into focus towards the end of the book. Here, he relates the story of the Scopes trial in 1925, when John Scopes, a high school teacher in Dayton, Tennessee, was convicted of violating the law prohibiting human evolution from being taught.

Spencer shows how, contrary to some accounts, few Christians at the time were upset about evolution because it contradicted a literal reading of the book of Genesis. What got people fired up, both the religious and otherwise, was the complex way in which some used evolution to inspire eugenicist views. I found the story of this whole complex episode fascinating.

He then leaps to the development of general relativity and quantum theory in the early 20th century. Here, I particularly enjoyed passages where Spencer tries to deduce what Albert Einstein thought about religion, drawing on his often cryptic references to God.

But his main objective is to illustrate how quantum theory, surely just as revolutionary as the theory of evolution, didn't cause anything like the same public brouhaha. This, he contends, is because science and religion clash most fiercely when they claim to make statements about what it means to be human.

"The arguments that ricocheted around the streets of Dayton in the 1920s were rich with human significance," he writes. "The theories of relativity and uncertainty and the observer phenomenon were not."

If you are the sort of person who thinks religion is nothing more than an immature fairy story, *Magisteria* will probably infuriate you. If, on the other hand, you have a more open mind, then prepare to read something genuinely fresh in what can be an extremely hackneyed debate. ▮

Freezing the future

Why do people want to be frozen after death? Could it get in the way of living? **Sandrine Ceurstemont** listens to a new podcast

Podcast

Frozen Head

Hosted by Alaina Urquhart and Ash Kelley

Wondery

FROM his childhood, Laurence Pilgeram was preoccupied with death. He would vividly imagine his parents in their caskets, wondering why people had to die. Pilgeram went on to build a lab on the family farm in Montana and experimented on guinea pigs, injecting bovine growth hormone into their pituitary glands to see if he could stop ageing and dying. "He was just so afraid of death," his brother Jim recalls.

Pilgeram became a vascular disease researcher and developed an obsession with cryonics – the practice of cooling a newly dead body so life might be restored when technology has progressed. He also signed up to be cryogenically frozen when he died. The *Frozen Head* podcast follows his quest and the stories of other cryonics supporters.

Some opt for the cheaper choice of preserving only their head, since our brains contain the critical parts of our identities and it is assumed that a body could be recreated in the future. "For Laurence and others like him, death isn't the end," says Alaina Urquhart, a novelist and autopsy technician who co-hosts the show with her niece Ash Kelley.

Sceptics argue that the odds of reanimating cryogenically preserved humans are low, but breakthroughs, such as the first successful thawing of a rabbit brain in an almost-perfect state, show the possibility is still open.

That said, cryonics can be shrouded in mystery, which can land its supporters in unusual situations. The podcast recounts why Mike Darwin was taken into police custody in the 1980s while he was the president of Alcor Life Extension Foundation, a prominent cryonics organisation. The police investigators were unfamiliar with cryonics and supposedly wanted to thaw the severed heads that the company had stored in liquid nitrogen. "They had no conception of what was involved," says Darwin.

Urquhart and Kelley previously hosted the popular true-crime podcast *Morbid*, and they are engaging hosts who bring out the human side of this macabre subject.

Cryonics seems to provide enthusiasts with an alternative way to deal with death. Baseball player Ted Williams's son, for example, wanted to freeze his father so he could spend more time with him some day.

The six-part series also shows the absurdity of trying to plan for what happens after death. Someone might be really committed to having their body frozen, but the complex logistics may not fall into place. Or, in some cases, people have been cryopreserved without enough proof it is what they want. Lengthy lawsuits often ensue, and can leave everyone unsatisfied.

Ultimately, the big question may be whether believing in cryonics prevents people from living life to the fullest. As Urquhart and Kelley say, people hoping for reanimation may live in denial of death, with a rose-tinted view of what "coming back" might be like. Aside from the improbability that the world would be a better place, they could, for example, be brought back in a body that they dislike. In Pilgeram's case, trying to control every aspect of his life and death backfired (to say more would be a spoiler).

Frozen Head is entertaining and informative, hinting at certain personality traits of many cryonics fans. This leaves me wondering whether people with other temperaments and motivations may also want to be frozen after death. And where are the women queueing up to be cryopreserved? Perhaps a sequel is in order. ▮

Mike Darwin was president of a cryonics company called Alcor Life Extension Foundation

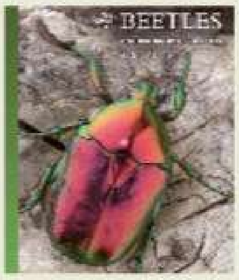
SIPA/SHUTTERSTOCK

Sandrine Ceurstemont is a writer based in Morocco

Don't miss

Watch

The Mandalorian begins its third season with a journey to Mandalore, spiritual home of protagonist Din Djarin and his fellow helmet-wearing warriors. The *Star Wars* spin-off is now streaming on Disney+.



Read

The Lives of Beetles are examined by entomologist Arthur Evans in a handsomely illustrated book, full of the latest findings. Considering that beetles make up one-fifth of all living species, it is remarkably concise. On sale from 7 March.

Visit

British Science Week is a 10-day, UK-wide celebration of science, technology, engineering and mathematics run by the British Science Association. The theme for this year's activities is "Connections". It starts on 10 March.

TOP: DISNEY

Where are we now?

An ambitious, weighty book tracks our complex relationship with Earth's climate. But more analysis would have been good, says **Michael Marshall**

Book

The Earth Transformed: An untold history

Peter Frankopan

Bloomsbury Publishing

HOW much of an influence has climate had on human history? How early in our existence did we begin to affect the environment? Can a sudden drought really cause a society to collapse? And what does "collapse" mean? These are just some of the questions that historian Peter Frankopan tackles in his ambitious new book, *The Earth Transformed*.

Frankopan is best known for his 2015 book *The Silk Roads,* which argued that human history was heavily influenced by commercial routes that spanned southern Asia. This time, his subject is the role of the environment in history: how the rise and fall of empires has been influenced by volcanic eruptions, storms and shifts in the climate, and how, in turn, societies have disrupted the ecosystems in which they exist.

The book is part of a genre that includes author Jared Diamond, of *Collapse* and *Guns, Germs, and Steel* fame. If anything, Frankopan is more ambitious than many other such writers, running from prehistory through the origin of farming and writing to the present. Frankopan also aims for a global account by including case studies from every continent.

Any such sweeping account will inevitably include some arguable claims. For instance, Frankopan is too accepting of the Toba bottleneck hypothesis: the notion that the eruption of the Toba supervolcano in Indonesia 74,000 years ago caused global cooling, devastating ecosystems and nearly driving humans extinct. This idea has been dismissed by many palaeoanthropologists for the lack of evidence of widespread ecological disruption at the time or of any impact on prehistoric humans. For me, the sections on prehistory were the weakest.

But, once Frankopan gets into recorded history, he hits his stride. As he works his way from the deep past to the present, he highlights how societies have come into conflict with nature and how those conflicts played out. Some of the examples, like the fall of the Maya elite, will be familiar. Others aren't yet widely known.

He handles some of the most famous cases of past climatic change with considerable care, avoiding the many pitfalls. His accounts of the fall of the Akkadian empire 4200 years ago and of the more recent Little Ice Age are both excellent.

"Our modern concerns about the environment are no modish fad: they were shared by ancient thinkers and leaders"

In particular, Frankopan avoids appealing but over-simplified narratives. For example, climate change can and does pose a threat to complex societies, but even dramatic shifts don't have to spell inevitable doom. Adaptation is always possible: the question is whether societies are willing to make the sometimes drastic changes necessary.

Ancient Maya's Pyramid of the Magician in Uxmal, Mexico

KONSTANTIN KALISHKO/ALAMY

Similarly, events that we label as societies "collapsing" are typically examples of them ceasing to build enormous monuments, or of the political elite losing power. Power structures collapse, but this doesn't necessarily mean mass deaths: indeed, for ordinary people, the collapse may be good news because their oppressors have been vanquished.

I have two concerns about *The Earth Transformed*. The first is that it contains so much detail that reading it is like being pummelled with facts and figures, with too little scene-setting.

The second is that, having expertly compiled such a vast amount of material, Frankopan has few insights to add. With so many examples of societies thriving or failing in the face of environmental crisis, I wanted to know why some did better. Is it more important to have free speech and democracy, or a powerful central authority that can enact sweeping changes? Can we make commerce and capitalism sustainable, or are they inevitably harmful? Frankopan has the material to explore such questions, but he doesn't.

It would be churlish, however, to complain too much. *The Earth Transformed* brings together an enormous range of material from around the world and millennia of human history. It reveals that our societies are, and have always been, intimately bound up with the natural world. Importantly, Frankopan shows our modern concerns about the environment are no modish fad: they were shared by ancient thinkers and leaders. Anyone with an interest in building a more sustainable world would do well to read his book. ▮

Michael Marshall is a science writer based in Devon, UK

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from the **The Prostate Project**

Men: don't put off that prostate test!

The Prostate Project is a volunteer-run charity based at The Stokes Centre for Urology, part of the Royal Surrey NHS Foundation Trust, in Guildford. Our ambition is to give men a better chance of beating prostate cancer, raising funds for research, diagnosis and ground-breaking treatment.

In 2019 we co-funded the £6m Centre, one of the most significant investments in Urological services in the UK for over a decade, helping to establish Royal Surrey internationally as a leading prostate cancer centre of excellence, capable of treating more men with early stage disease than any other unit in the UK.

We also fund scientists working at the University of Surrey, supporting their work developing innovative immunotherapy treatments and drugs for men with advanced (metastatic) prostate cancer.

2023 will see the launch of our most ambitious effort since the Centre opened with the introduction of the 'ManVan', a mobile PSA blood testing clinic, providing easy access to testing for men across the region. The PSA test is a simple blood test used to help detect prostate cancer.

The stark fact is that prostate cancer claims a life every 45 minutes, that's 12,000 UK men a year. But hope is provided by increasing the awareness of men over the age of 50 that, with early diagnosis, prostate cancer is one of the most treatable cancers and this latest initiative will help to ensure even more positive outcomes for men in and around Surrey, Sussex and Hampshire.

The Prostate Project is on a mission to let every son, dad, uncle, brother, grandad and husband know that they need to get tested.

Want to know more?

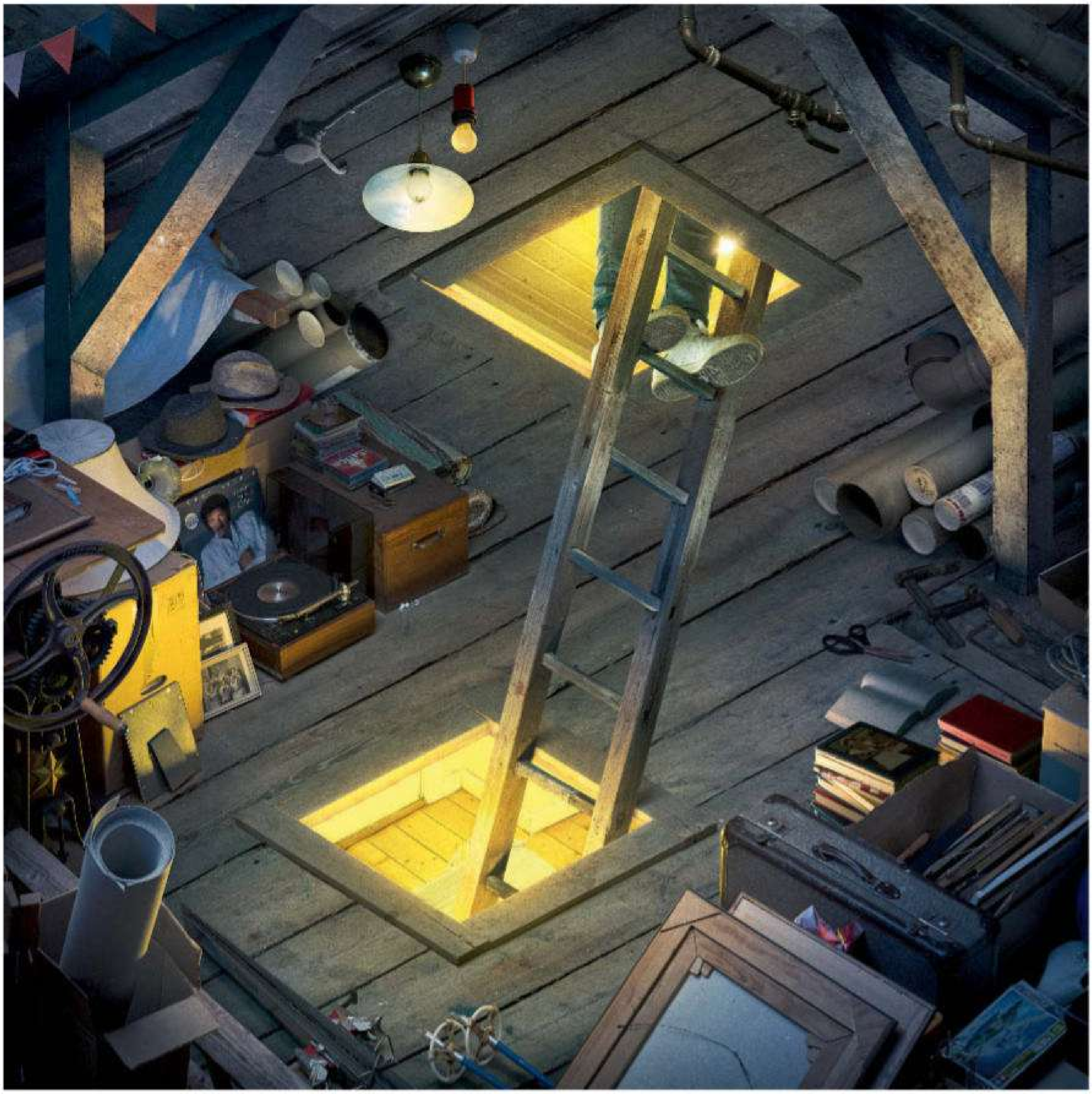
For more information about the Prostate Project, or to make a donation, please visit www.prostate-project.org.uk. If you are over 50, have a family history of the disease or are from an ethnic minority, there's no need to wait for the mobile clinic, just contact your GP to discuss the PSA test.

Do you need your signal boosted?

If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

Another level of weirdness

We have glimpsed an even stranger version of quantum theory. Now it is time to put it to the test, says physicist **Ciarán Gilligan-Lee**



ERIK JOHANSSON

“EINSTEIN attacks quantum theory.” That was the headline in *The New York Times* on 4 May 1935. The world’s most famous scientist and two collaborators had discovered what they saw as a fatal flaw at the heart of our greatest theory of nature. They had found that particles separated by kilometres seemed to be able to interact instantaneously with each other. Albert Einstein called it “spooky action at a distance”.

Even though he had helped lay the foundations of quantum theory, Einstein felt it must be missing something. That spookiness just didn’t feel right – there must be something we weren’t seeing that could explain it. No idea this strange could be true, surely?

We now know that it is. That is the lesson from most of the past century of physics, as quantum theory, including spooky action at a distance, passed every experimental test thrown at it. At the tiniest scales, reality really is as strange as our best theory of the subatomic world suggests.

What we haven’t figured out is why quantum theory is so strange. Physicists like me have long been examining its foundations in search of answers. Recently, these efforts have turned up a major surprise: a new hypothesis called “almost quantum theory” that is even more bizarre than the original. What really excites me is that we might be on the cusp of putting it to the test. If it passes, the newspapers will be reporting the scientific upset of the century.

Quantum theory deals with the subatomic world of particles, and it describes their behaviour with peerless accuracy. It is often spoken of as the most bulletproof scientific theory. But that doesn’t make its ideas any easier to digest. Among its strange facets is that subatomic particles can exist in a cloud of possible states called a superposition before they are measured – the counterintuitive nature of which is most famously captured by Schrödinger’s cat, the thought experiment about a feline that is simultaneously dead and alive. Then, there is the fact that light, say, can behave as both a particle and a wave.

But it is Einstein’s spooky action at a distance, more properly known as non-locality, that bamboozles us most. Take two particles, prepared using a special procedure known as quantum entanglement, and send them far apart. If you peek at one, you will immediately be able to discern some of the quantum properties of the other. It seems that they influence each other instantaneously over large distances, even though no influence takes place. “Spooky” really is the word.

Odd socks

To grasp non-locality more fully, it helps to consider an anecdote about odd socks first told by the Irish physicist John Bell, who greatly advanced our understanding of the quantum world. It was inspired by Reinhold Bertlmann, who worked with Bell in the late 1970s. Bell realised his colleague had a habit of wearing a different coloured sock on each foot. This meant that as soon as you saw that one of Bertlmann’s socks was pink, for instance, then you knew the other one wouldn’t be pink.

Bell thought that sounded suspiciously similar to entanglement. It made him wonder if entanglement was as odd as it seemed. The socks anecdote can be explained easily enough by Bertlmann’s choices as he dressed. Could the correspondence between entangled particles be similarly predetermined – thus explained by everyday, non-quantum physics?

Bell’s genius was to answer this question with what has come to be known as the Bell test. It involves entangling two particles and sending them far apart, to labs where they can be measured in two different ways. Each lab makes one measurement, not knowing which one the other lab has chosen, and uses that to predict things about the result of the other lab’s measurement. Think of it as the quantum version of looking at the pink sock and predicting that the other sock isn’t pink. They do this lots of times and count up the number of correct predictions. Bell showed that if entanglement can be explained by everyday, non-quantum physics, you would get the right answer in a Bell test no more than 75 per cent of the time. When the test is conducted on quantum entangled particles, however, the right answer emerges 85 per cent of the time.

Bell’s test, then, was a way to quantify how weird the correlations between quantum particles are – and it showed that they really do exceed anything we can explain using classical physics. This is what we really mean when we talk about “non-locality”.

Reading about this is what first got me interested in becoming a physicist. The fact you could ask such deep questions about reality and get a clear answer fascinated me. Now, Bell’s test is playing a key role in the development of a set of ideas even stranger than quantum theory.

These ideas had their genesis 30 years ago, when researchers wondered if there were a single principle at the heart of quantum theory. To see why that matters, compare quantum theory with Einstein’s theory of special relativity. This was built chiefly from the basic principle that nothing can travel faster than light. If quantum theory can be similarly derived from one principle, a kind of essence of quantum, it would not only be highly elegant, it might also show us

DILLON VERSPRILLE

where the weirdness ultimately springs from.

In 1994, Sandu Popescu at the University of Bristol, UK, and Daniel Rohrlich at Ben-Gurion University of the Negev in Israel were mulling this over. They came up with a potential theory of physics that mathematically formalised just two simple principles. First, no signals can go faster than the speed of light. Second, non-locality applies to reality. It all seemed routine. But they were in for a shock.

It turned out their idea, known as PR boxes, allowed for much stronger correlations than we observe. A Bell test would produce the right answer 100 per cent of the time. It seems obviously mistaken, but PR boxes started from reasonable assumptions, so why was it wrong? "It was a huge surprise," says Mirjam Weilenmann at the Institute for Quantum Optics and Quantum Information in Austria.

This result went largely unnoticed for a time. "Their work appeared in a somewhat obscure journal," says Matty Hoban at Quantinuum, a quantum computing company in Oxford, UK. But a little over a decade ago, some physicists began to investigate further.

One was Miguel Navascués, also at the Vienna institute. In 2009, he too decided to reformulate the rules of quantum theory, this time starting from the principle that nothing travels faster than light and a new principle called macroscopic locality. The latter says that, as we move from particle-sized objects to the larger, macroscopic world, the rules of classical physics emerge and non-locality vanishes. A Bell test under these assumptions showed the right answers for entangled particles must occur less than 100 per cent of the time. It suggested that PR boxes had gone off the rails because it left out the principle of macroscopic locality. There was now a feeling that this kind of research might inch us closer to finding the essence of quantum theory.

"THIS RESEARCH MIGHT INCH US CLOSER TO FINDING THE ESSENCE OF QUANTUM THEORY"

In the same year, a team led by Marcin Pawłowski at the University of Gdansk in Poland tried the reformulation trick again, this time starting from a single principle called information causality. This says that when two people exchange information, one can't receive more than the other sent. This proved decisive. A Bell test performed under the resulting formulation would produce the right answers 85 per cent of the time, the maximum level of accuracy observed in real experiments.

This caused quite a stir. "Information causality was an enormous success, it was amazing," says Navascués. Some thought that we might finally have hit on the essence of quantum theory. "People said maybe this principle encapsulates all of quantum mechanics," says Navascués. But he wasn't so sure. He didn't think the authors had done enough to show that their framework could describe all the nuances of quantum physics,

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not least the other strange phenomena beyond non-locality.

So, Navascués, Hoban and their collaborators came up with yet another proposal in 2015. It misses out some of the information contained in quantum theory proper, which is why it has become known as almost quantum theory. But it seems to come with everything we know to be true about quantum theory baked in. What's more, when you work through the result you would get from a Bell test under almost quantum theory, it again comes out as about 85 per cent. Navascués and his collaborators had achieved their aim of showing the flaws in information causality because that principle didn't uniquely reproduce quantum theory.

It might seem a downer that information causality had been found wanting. But when you think it through, there is an exciting alternative: what if almost quantum theory is actually the true description of reality?

In almost all situations, it makes the same predictions as regular quantum theory. Yet there are some unusual instances where, in a surprising twist, it predicts that there would be correlations between particles that are stronger than plain vanilla quantum theory does. None of these situations has so far been experimentally investigated. So that leaves us in a historic position. We have a potentially viable theory of reality that we can't rule out, and it suggests that, in some circumstances, quantum theory isn't weird enough to do justice to reality.

As if that weren't thrilling enough, there is another reason to get excited about almost quantum theory. One of the biggest missions of physics is to find a more unified description of reality. At the moment, our theories of gravity and the quantum world are separate beasts, and a promising way of uniting them would be to find a quantum version of general relativity. It turns out that almost quantum theory has a similar mathematical structure to one candidate for a theory of quantum gravity, known as the consistent histories formulation of quantum gravity. The building blocks of this hypothesis, proposed by Nobel prizewinner Murray Gell-Mann, correspond to sequences of particle interactions. The idea isn't currently popular and this could all be a coincidence. Or it could be telling us something. "I thought it was a really cool connection," says Hoban.

Something to hide

It is vital that we find out if almost quantum theory stands up. But it won't be easy. It predicts that, in certain situations, particles can have stronger correlations than we have ever observed. But, by definition, the systems of particles involved will be harder to control and work with. One way to put it to the test might be to conduct a version of the Bell test with three particles instead of two, says Ana Belén Sainz, also at the University of Gdansk. "I would love to see these experiments," she says.

The only trouble is, we don't yet know what kinds of particles would be best for such tests. Familiar ones like electrons or photons aren't likely to be hiding much. But Navascués says there are systems of quantum particles that we have always struggled to control – particles like kaons, which are composed of quarks bundled together in an unusual way. He thinks these might be hiding post-quantum physics.

Another place to look for this is inside quantum computers, says Hoban. Within these machines, lots of particles interact in ways we can't always understand. "I would love it if we start building these quantum computers and, suddenly, they're not behaving as they should," says Hoban. This could be a sign of almost quantum theory. Navascués agrees that looking at systems where large numbers of particles are interacting might be fertile ground. He is talking with a group of experimentalists in China to explore how they could design systems like this and test them.

If almost quantum theory turns out to be true, there will be major implications. The ability to entangle particles underpins quantum computing and quantum cryptography. Quantum computing promises a revolution by providing a totally new way to do calculations. Quantum cryptography offers a reliable way to secure communications and could form the basis of a quantum internet. If almost quantum theory is true and we can harness it, it could supercharge both technologies.

Even if all this turns out to be smoke and mirrors, the search for new principles of physics is valuable. The more we learn about quantum theory, the better the chance we might find a way to reconcile it with general relativity, Einstein's theory of gravity. "Quantum theory is already super old compared to other theories, but there are so many new avenues people explore all the time," says Weilenmann.

Speaking of Einstein, you have to spare a thought for him in all of this. He fervently hoped that spooky action at a distance was a flaw that would end up showing quantum mechanics was wrong. Little did he know that 90 years later we might be about to find an even spookier theory of physics. ▮

Ciarán Gilligan-Lee is a physicist affiliated to University College London and Spotify, where he leads an AI research lab. Follow him on Twitter @quantumciaran

SERGIO MEMBRILLAS

The baby dilemma

Whether or not you have children can have a big impact on your health and happiness, and on the planet too. Can science help guide your decision, asks **Abigail Beall**

YOU could say my enthusiasm for parenting peaked at the age of 4, when I was cast in the leading role in the school nativity. I took my responsibilities as Mary extremely seriously until, during a high tempo carol on the big night, I dropped the baby Jesus – a doll, just to be clear – on its head. I was never given a named part again.

I don't know how many young girls play with dolls because they are fascinated with babies, or simply because it is what society suggests they should do. But I do know that, as a child, I had no interest. If baby Jesus had been a plastic dinosaur or an astronaut, I might have held my focus. However, while I didn't grow up with strong aspirations to become a parent, it is a question that is increasingly on my mind. I am now married, some of my dearest friends are expecting babies and I turned 30 last year. With these life events comes societal expectations and pressure. But I am not sure what I want.

I am not alone. In the UK, 38 per cent of people aged 25 to 34 say they don't know if they want children or say they don't want kids now but might one day. Around the world, birth rates have plummeted – and among those who have children, a significant number regret it. To avoid becoming one of them, I want to set aside the emotional baggage and cultural expectations and find out whether the cold hard facts can steer me in the right direction.

I start with the big question, the one that seems to crop up time and again in conversations and articles I read: what impact does adding a person to the world have on the environment? One review paper from 2017 looked at the personal choices someone in a high-income country can make, pitting their environmental merits against each other. Eating a plant-based diet would typically save the equivalent of 0.8 tonnes of carbon dioxide a year. Avoiding flying would save 1.6 tonnes per transatlantic return trip, while living without a car would save 2.4 tonnes a year. Yet have one fewer child and you emit a whopping 58.6 tonnes less a year, on average – the equivalent emissions of burning about 24 tonnes of coal.

This seems huge, and there is a reason why. "If you're talking about the decision to have a child, the counterfactual is not creating an additional person," says Kimberly Nicholas at Lund University, Sweden, who coauthored the review. If you decide to create an additional person, says Nicholas, the 58.6 tonnes takes into account not only that child, but their potential children, grandchildren and so on. "It adds up to a really big number."

This number isn't set in stone, however. The estimated 58.6 tonnes is an average for high-income nations – the impact of having children varies hugely depending on which country you live in. And unlike flying or eating meat, emissions from a future child and the rest of their lineage will be produced much further down the line, so that full 58.6 tonnes won't hit right now while we are urgently striving to cut emissions.

Moreover, as we head towards a lower-carbon world, adding a new person into the mix will have an ever-lower impact, so my potential kids are likely to have a smaller carbon footprint the older they get. It will never be zero, says Nicholas, but it will be much lower than today. Even so, if I waited until the UK reaches net zero before having children, I would be 58 based on the current target. Holding out until then isn't really an option.

The happiness penalty

For fear of throwing the baby out with the environmental bathwater, I move on to the next big issue on my list: happiness. People who are parents often say that having children is the best thing they have done in their life. And yet many of them seem constantly stressed and tired. What does the evidence say?

Here, there is plenty of research and its findings may be disturbing to prospective parents. "The studies on wealthier, industrialised countries pretty much all show the same thing," says Jennifer Glass at the University of Texas at Austin. "There is no general improvement in happiness when you have children, which is shocking to most › people.” In fact, for most, having children comes with a “happiness penalty”, says Glass.

That dip in happiness is often attributed to lack of sleep, time and money, which, in turn, can depend on things like the parents’ income and stage of life. People who have children when they are over the age of 30 tend to be happier – which is music to my ears. But on the money side, living in the UK doesn’t bode well. Glass has found that the happiness penalty is larger in the US and the UK than in many European countries. In France, Norway, Spain and Sweden – where there is cheaper or more freely available childcare, for example – the joys of parenthood balance out the stresses. Data published by the UK Office for National Statistics in June 2022 showed that a full-time nursery place for a child under 2 costs 65 per cent of the median take-home pay of a working adult. In the US, the situation seems even more dire. “Over the past few decades, the act of just bearing a child is increasingly likely to push a mother’s household into poverty in the US,” says Glass.

Further evidence for money’s crucial relevance to the baby question comes from research published in 2019 by David Blanchflower at Dartmouth College in New Hampshire and Andrew Clark at the Paris School of Economics. They looked at surveys completed by more than a million people in Europe over 10 years and found that, when money is taken out of the picture, having children does generally make people happier after all. However, this was only the case for parents in a committed relationship, not those who are single. My husband and I are pretty rock steady, which is also good news, but it does make me consider the stress that parenting could put on my marriage.

Indeed, a study from 2021 gave me more to reflect on. In it, Marta Kowal at the University of Wrocław, Poland, and her colleagues surveyed more than 7000 married people from 33 countries who were asked to rate how much they agreed with questions like “Do you enjoy your husband’s/wife’s company?” or “Do you enjoy doing things together?”. The researchers found that the more children a couple have, the lower the marital satisfaction among women, but not men (see “What’s the magic number?”, left). But even if children don’t make people happier on the whole, there could be more profound benefits, says Glass, “like life satisfaction, a sense of meaning or purpose in life, all of which can improve after having kids”.

WHAT’S THE MAGIC NUMBER?

What can research tell us about how many children will make us happiest? The answer seems to be at least partly down to culture, as study results vary in different countries.

When sociologist Hans-Peter Kohler at the University of Pennsylvania surveyed identical twins in Denmark who had chosen to have children, he found that both men and women became happier with the birth of their first child. For men, having a son made them feel 75 per cent happier compared with having a daughter. On the arrival of a second child, the men saw negligible change to their happiness, while the women’s happiness decreased, implying that, for the greatest happiness, one is the magic number.

But research on people becoming parents in Germany and the UK has found that happiness increases with the first and second child, but not the third, suggesting you should stop at two. Why the disparity? We already know that many other factors, such as age and wealth, play a part (see main story). Whether the number of children you have matches how many you hoped to have is also important.

Catherine de Lange

Another question weighing on my mind is the physical toll of pregnancy and birth. There is almost no system in my body that wouldn’t be affected by having a child, with some changes lasting much longer than others.

To start, studies suggest that giving birth is associated with shorter telomeres – the caps at the end of chromosomes. This shortening is the equivalent of around 11 years accelerated cellular ageing. Then there is physical fitness. Despite expectation from society, it can be incredibly hard for even the very fittest to get back to the same level after having a baby.

We also hear a lot about the effects of pregnancy on the brain, particularly its potential impact on cognitive abilities, or so-called baby brain. “There are still many things we don’t know about how pregnancy affects the brain,” says neuroscientist Elseline Hoekzema at the Amsterdam University Medical Centers in the Netherlands. Research by Hoekzema and others in recent years

CATHERINE FALLS COMMERCIAL/GETTY IMAGES

Having children doesn’t appear to increase maturity

suggests that hormones may have an impact on the structure and function of the brain during pregnancy. The changes to structure seem to be long-lasting, while the changes to function are temporary, but they all appear to be linked to the mother's behaviours, helping her respond to the baby's needs and cues and assisting with bonding, says Hoekzema. When she and her colleagues tested these mothers' cognitive abilities, they found no changes, which is a relief.

Even more concerning to me were the statistics I found relating to mental health. More than 1 in 10 mothers develop postnatal depression within a year of giving birth, and the same percentage of expectant mothers experience antenatal depression. And while maternity-related deaths in the UK are rare, a 2022 report published by the University of Oxford showed that deaths from mental health-related causes account for nearly 40 per cent of deaths occurring within a year after the end of pregnancy. There aren't many studies into the mental health of adoptive parents, but some suggest up to a third experience depression. All told, it indicates that improved care for new parents is desperately needed.

I had also held grandiose ideas that becoming a parent – the ultimate responsibility – would make me feel like more of a grown-up, but it turns out that having a child doesn't necessarily make you more mature. A 2020 study by Eva Asselmann and Jule Specht at Humboldt University of Berlin, Germany, studied data from about 6900 people who had become parents between 2002 and 2017 and who were participants in a long-running study that included personality tests. They found that becoming a parent made people more extroverted, less open and, for women, more agreeable. But they didn't find any increase in emotional stability, which is linked to maturity. Overall, the personality changes were all small and tended to be temporary, lasting a few years.

Looking at all the evidence, I start to wonder why anyone decides to have children. It would cost me dearly in terms of money and probably happiness too, change my body and my brain, and could put my marriage under strain. No wonder, then, that in my research I come across Reddit and Facebook groups called things like "regretful parents" and "I Regret Having Children". These appear to be safe havens for people who feel shame about their regret, but wish they had made a different decision. Reading the posts from mostly anonymous parents – some a few months in, some decades down the line – is eye-opening.

BLEND IMAGES - JGI/JAMIE GRILL/GETTY IMAGES

Childcare costs 65 per cent of the UK's average pay

Love not logic

But it isn't representative of most parents. Surveys of people in the US and Germany suggest that, at most, 17 per cent wouldn't have their child if they could make the decision again, but in most places this figure is much lower. It is also possible that, for many of them, the sense of regret is transient.

What's more, in some cases, the regretful parents didn't have reproductive choice in the first place. Some were denied access to contraception or abortion, for example. Others talk about having children without really questioning whether they wanted to or not. I can't find a huge amount of research on the reasons people give for having children, but one study led by Jacky Boivin at Cardiff University, UK, published in 2018, found that reasons varied hugely depending on where people lived. In some countries, a big factor was that childless people are stigmatised in society; in others, people's own desires or wanting to comply with pressure from partners or family members was more important.

It seems obvious that nobody should feel like they must have children to avoid stigma from society. But are there universally good and bad reasons to have kids? Yes, says bioethicist Travis Rieder at Johns Hopkins University in Maryland. If, for instance, you had children to supply the state with future soldiers, reverse the trend of falling birth rates or even simply to provide your parents with grandchildren, these are probably bad reasons, he says. "It's treating your future children as a means to yours and society's ends."

Equally, however, there are potentially good reasons to have children that aren't easily quantifiable. "When we have it as a central goal of our lives to experience creation, and to form a family, perhaps with a person who you deeply love," he says, "this sort of value can ground a good moral reason to make a new person."

In the end, perhaps the cost to the planet, my finances and my physical and mental health aren't the right issues to be considering. "My advice to prospective parents is to really reflect on the reasons that they would have children and to see if those reasons are based in the value of love and creation," says Rieder.

Even if I didn't find conclusive answers in the scientific research, when I come to make my decision, I now know a lot more about what I would be letting myself in for. Who knows, maybe one day I will rekindle the zeal for parenting I thought I had dropped, along with the baby Jesus, in December 1996. ▮

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries

Abigail Beall is a features editor at *New Scientist*

Rising waters

Lakes across the world are experiencing record-breaking levels of water rise, threatening animals and displacing people. It is a dangerous trend with a clear culprit, finds **Graham Lawton**

JAMES WAKIBIA/SOPA IMAGES/LIGHTROCKET VIA GETTY IMAGES

ON THE shores of Lake Baringo in Kenya, a slow-motion disaster is unfolding. For the past decade, the water has been steadily rising, swallowing homes, shops, health centres, latrines, electricity supplies, farmland, tourist resorts and more. Malaria, cholera, typhoid and dysentery are increasing. Wildlife is under threat; conflict has broken out between people and animals and old grievances between neighbouring groups have resurfaced.

Since it started rising, Baringo's surface area has more than doubled, and it isn't alone. Right across the East African Rift valley, lake water is creeping over animal and human heads. And where East Africa leads, much of the rest of the world is following. North America's Great Lakes have been rising too. Overall, lakes the world over have expanded to occupy an extra 46,000 square kilometres of space since 1984, roughly the area of Denmark.

When we talk about inland water bodies, dwindling ones such as the Aral Sea in central Asia, Lake Chad in central Africa and the Great Salt Lake in Utah dominate the conversation. But the global trend is actually the opposite. The cause of these increases has been debated for years, but the consensus has now settled on the real culprit: us. You have probably fretted about impending sea-level rise. Welcome to the untold story of another human-made catastrophe in the making: lake-level rise.

The East African Rift valley stretches from Ethiopia in the north to Mozambique in the south via Kenya, the Democratic Republic of the Congo (DRC), Uganda, Rwanda, Burundi, Zambia, Tanzania and Malawi. It is home to dozens of lakes, including the five largest in Africa: Victoria, Tanganyika, Malawi, Turkana and Albert.

The most detailed information on lake-level rise comes from Kenya, which is home to Turkana – the world's largest permanent desert lake – a bite-sized chunk of Victoria, eight other large lakes, including Baringo, and the Turkwel Gorge dam. All are on an upward trend, with major consequences for the millions of people who live around them.

"What you see are submerged houses and reduced stability of the land around the lake," says Maxwell Onzere at the University of Nairobi, Kenya, speaking about Lake Nakuru. "Some people have had to find new places to live. Most of them, their livelihoods depend upon this lake. When it bulged outwards, they had to find other sources of livelihood. Even the gate of the [Lake Nakuru] national park, it got submerged into the water."

Kenya's diluvian disaster was first reported in 2013 by Simon Onywere at Kenyatta University in Nairobi. He and his colleagues were taking measurements for another project when they inadvertently found that all four lakes in their study – Baringo, Bogoria, Naivasha and Nakuru – had risen alarmingly in the past few years. At Naivasha, the entire lake-fringe of papyrus and acacia trees was underwater. Nakuru's flamingos, a big tourist draw, were nowhere to be seen.

Onywere proposed that the rising waters were the result of a natural 50-year climate cycle, as similar flooding had been recorded in Kenya in 1901 and 1963, though not well documented. However, Onywere was unaware of recordings from elsewhere in the region that drowned this 50-year-cycle hypothesis at birth. In 1981, Geoff Kite at the United Nations Development Programme (UNDP) in Nairobi had published a paper showing that the level of Lake Victoria had risen by 2.5 metres between October 1959 and May 1964. It then fell back slightly, but started rising again in 1978 and was still rising at the time of publication. The same was true of three other lakes: Malawi, Tanganyika and Albert.

Kite explored the reasons for the rises and concluded that no human activity could account for it. But he admitted that he couldn't pinpoint a natural cause either.

Almost as soon as Kite published, Victoria started to recede again. By 2007, it had fallen

> "People have had to find new places to live. Their livelihoods depended upon this lake"

Thousands of people have lost their homes near Lake Baringo, Kenya

to more than 3 metres below its 1964 peak and there were fears that it was irreversibly drying up. It wasn't. Victoria did another U-turn and, apart from a brief hiatus, its waters have been rising ever since. According to a 2021 report by the Kenyan government and the UNDP, the surface area of the lake increased by more than 500 square kilometres, or 13 per cent, between 2010 and 2020.

Kenya's 10 other major lakes are expanding too. UNDP describes the situation as a "crisis". More than 380,000 people have been displaced and are in "dire need" of humanitarian assistance, having lost livelihoods, schools, utilities and sanitation. Several people have been killed by hippos, which now graze nearer human settlements.

"The rising lake water levels and accompanying flooding have stirred panic and anxiety among the surrounding communities where the floodwaters have left trails of destruction," says Keriako Tobiko, cabinet secretary of the Kenyan Ministry of Environment, Climate Change & Forestry. The environment and wildlife have suffered as well.

Lakes in other East African countries have been rising rapidly too. Tanganyika, which straddles Tanzania, the DRC, Burundi and Zambia, has been on an upward trend since 2006 and hit record levels in 2021. Last year, Lake Malawi – shared between Malawi, Mozambique and Tanzania – recorded its highest level for eight years.

Placing the blame

The exact cause of the rising waters has long been debated. There are three possibilities, none of them mutually exclusive. One is natural climate variability, with greater rainfall the main driver. Another is natural geological activity: the rift system is tectonically dynamic and shifting plates under the lakes could conceivably change water levels. The third is human activity – principally global warming, which increases rainfall, and land-use change leading to increased water runoff into the lakes and greater sedimentation, which raises the lake bed and blocks outflow streams.

Right now, the finger points firmly at human activity, especially climate change. A 2021 study of water levels in Kenya's lakes Baringo, Bogoria, Nakuru, Solai, Elementaita and Naivasha concluded that changes in rainfall were sufficient to explain the rises. Even though much of East Africa is in drought, the rift lakes region has seen increased rainfall. "Climate change is a major cause of the rising water levels," says Onzere, the co-author of another study that largely attributes Nakuru's 8-metre rise to warming.

Not everyone agrees, however. "The preferred scapegoat is always climate change, but I see anthropogenic land use change as the critical factor altering the hydrological cycle," says Sean Avery, an engineer and hydrology specialist at King's College London who is based in Kenya.

Tectonic activity also hasn't been ruled out. A recent study of Lake Beseka in Ethiopia, which covers an area about five times its extent in 1972, found that rainfall actually declined over the period. According to the researchers, the most plausible explanation is tectonic activity, which has torn open the lake bed, allowing groundwater to seep in, and has created new basins in which water can collect.

Nevertheless, the Kenyan government report is very clear on where it places blame. "The main reason for the rising water levels is climate change," it says.

As usual, then, the Global South is bearing the early brunt of climate change. But Western countries largely responsible for emissions aren't immune.

"Several people have been killed by hippos, which now graze nearer human settlements"

TONY KARUMBA/AFP VIA GETTY IMAGES

Locals fish in flood waters at Lake Naivasha in Kenya

TODD BANNOR/ALAMY

High water levels in Lake Michigan in 2020 (left) caused erosion and property damage (right)

CORY MORSE/THE GRAND RAPIDS PRESS VIA AP/ALAMY

> "Many of Bogoria's hot springs have been submerged and vast flocks of flamingos decimated"

A hemisphere away, other bodies of water are also on the rise. In 2013, Lake Michigan in the US was at a record low, but then started rising rapidly and hit record highs in 2021. Nearby lakes Superior, Erie and Huron also hit record highs; the last of the five North American Great Lakes, Ontario, was well above average too. The waters have receded somewhat since then, but left behind a lot of coastal erosion and flood damage. Some 40 million people live near the shores of the Great Lakes in the US and Canada.

Rise, fall and repeat

At last year's American Geophysical Union (AGU) hydrology conference in San Juan, Puerto Rico, Lauren Fry at the US National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Lab reiterated the cause. Climate change is affecting all three of the factors that control lake levels, she said. These are precipitation over the lakes, runoff from the land and evaporation.

The lakes have risen and fallen quickly in the past, but never quite as fast. There is a historically rapid change in both directions, says Riley Balikian at the Illinois State Geological Survey.

Similar surges are forecast in the future. A model presented at another recent AGU conference in Chicago predicted that the Great Lakes could rise by half a metre or more by 2050, exposing people and nature to greater damage from storm surges and flooding.

Other models are more circumspect. According to Alexander Vandeweghe at the University of Michigan, it is still unclear how climate change will influence the three drivers of lake levels in North America. "There's significant variability and uncertainty," he says. Some models show large increases, others slight declines. What we can say is that water level variability in the future will be at least as great as it has been in the past, says Vandeweghe.

This story of lake-level rise is being repeated across the globe. Last year, a team led by Lian Feng at Southern University of Science and Technology in Shenzhen, China, analysed satellite images of all of Earth's 3.4 million lakes and reservoirs from 1984 to 2019. The team came up with the 46,000-square-kilometre expansion figure mentioned earlier, but found that, if you eliminate lakes that are shrinking, the growth amounts to 167,000 square kilometres.

Around half of that involves reservoirs, but the rest is natural lakes. This spells further bad news for the climate. Lakes of all sizes are prolific sources of greenhouse gases because the decomposition of organic matter on their beds produces carbon dioxide, methane and nitrous oxide. Lakes account for an estimated 20 per cent of global emissions.

According to the study, the extra lake area over the course of the study increased carbon emissions by 4.8 million tonnes a year, roughly the same as Kenya's annual emissions.

Back in Kenya, fears are growing that the rising waters of Baringo will impose ecological disaster on its neighbour, Bogoria, a world heritage site and well-known tourist destination. Many of Bogoria's famous hot springs have already been submerged in recent years and it has seen vast flocks of flamingos decimated. But worse is to come if Baringo creeps any nearer. Bogoria is a salty, alkaline lake, which is what makes it attractive to flamingos. Baringo is freshwater. If the two merge, Bogoria's ecosystem will be ruined. The two are in the same basin and used to be 20 kilometres apart, but are now just 13 kilometres from each other.

For the foreseeable future, the lakes will carry on getting bigger. "If we continue doing things the way we are doing, it means levels are going to rise," says Onzere. "Only if we have normal temperatures and normal rainfall amounts will the lakes come back to normal." The world isn't just burning, it is drowning too. ▮

Graham Lawton is senior reporter at *New Scientist*

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Stargazing at home

All light on the night

Light pollution is an issue for astronomers, but you can limit your contribution – and find a dark spot near you, says **Abigail Beall**

Abigail Beall is a features editor at *New Scientist* and author of *The Art of Urban Astronomy* @abbybeall

What you need

Access to an interactive dark sky map from a site like DarkSiteFinder.com

I AM a firm believer that you can stargaze anywhere. In fact, a few years ago, I wrote a book about stargazing from cities based on that very premise. My argument is that stargazing can sometimes be easier to do from urban areas, especially for people who are new to the pastime and want to learn their way around the night sky. In a dark sky filled with stars, you can be overwhelmed by the sheer number of them and can lose the patterns of the constellations.

Having said that, I am very concerned about light pollution, particularly after reading a recent study in *Science* suggesting that, from 2011 to 2022, light pollution has got worse – and quickly. It reported the results of a citizen science project that collected information from people all over the world, totalling more than 51,000 observations of the night sky, finding that it is brightening by close to 10 per cent each year.

Light pollution isn't just a problem for stargazers. It is a driver of biodiversity loss, particularly affecting birds. It harms human health too, with an influence on mental health and links found to some cancers. It is also a huge carbon emitter – the energy used sending light into the sky is simply a waste of electricity.

The International Dark Sky Association has a simple set of guidelines that people can follow to limit their contribution to light pollution. This includes making sure that any outdoor light you install is necessary, only points exactly where you need it and is only used when required. You should also limit the amount of blue light in your outdoor lighting. Just as you may have heard about blue light emitted by electronics, blue light outside at night is bad for our circadian rhythms. It is also worse than warmer-coloured light for throwing off your eyesight as you look for dim objects in the sky.

CHRISTOPHER SWEET/EYEEM/GETTY IMAGES

The biggest culprits for light pollution in cities are things like streetlights and bright lights from big commercial premises, such as supermarkets. You can write to your local government if you are concerned about unnecessary light pollution in your area.

It isn't all doom and gloom, though. Countryside charity CPRE has run a UK annual star count each February since 2019 to build up a picture of how light pollution is changing. By its estimates, in the UK at least, light pollution got better during the pandemic and, by 2022, still hadn't got worse. The results of this year's count are due soon.

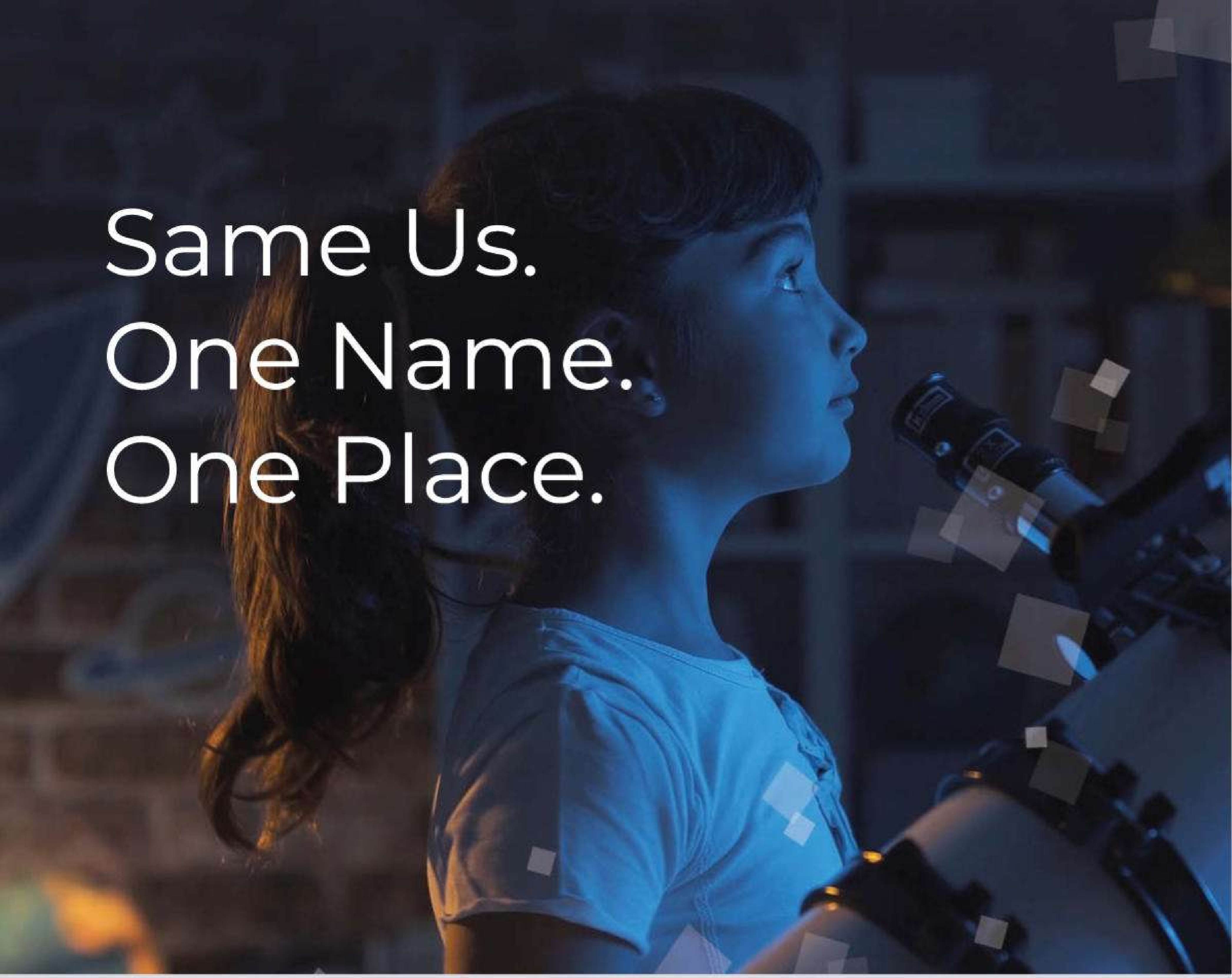
If you live in a light-polluted city and want to find somewhere dark to view the things you won't see from your house, like the band of the Milky Way or the Andromeda galaxy, you can use a global interactive dark sky map from a site like DarkSiteFinder.com to find the best location near you. Mine is the Northumberland National Park, which is the UK's biggest designated dark sky area. ▮

Stargazing at home appears every four weeks. Share your stargazing successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistStargazing

Next week

Science of gardening

These articles are posted each week at newscientist.com/maker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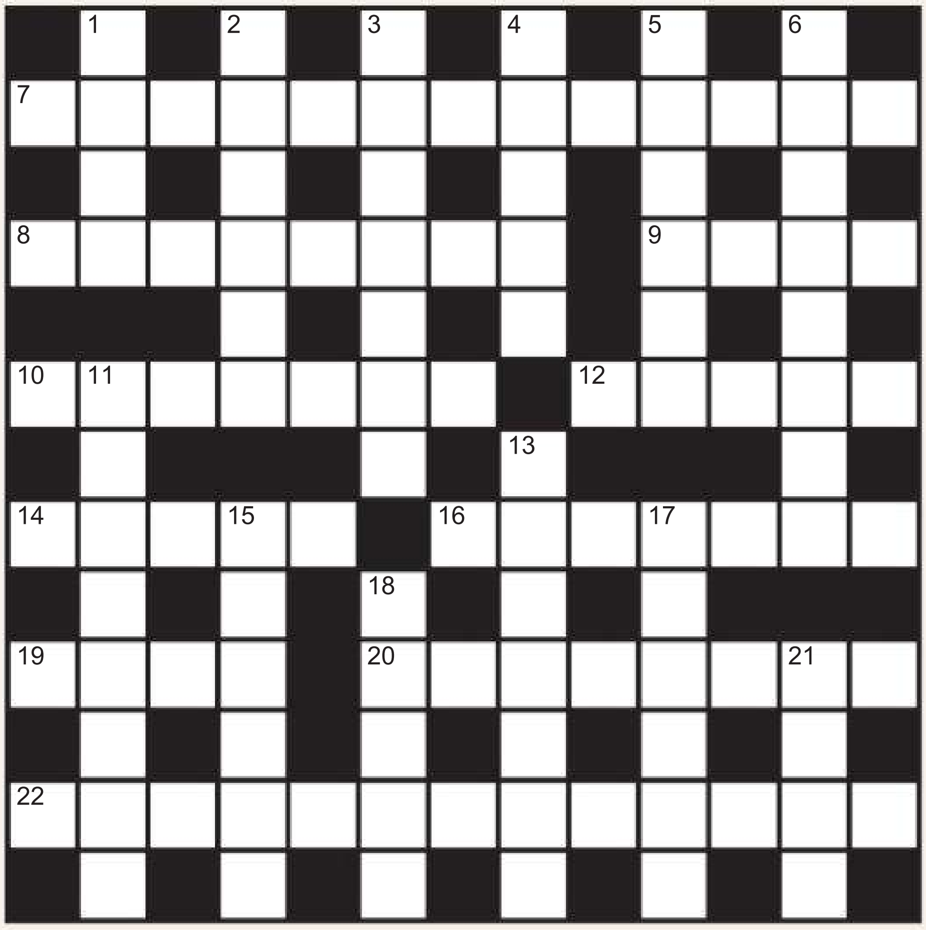

Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Widely used medicine – he maintains it works (13)
8 Astronomical diagram made by pedantic Austen character (8)
9 Instrument got broken regularly (4)
10 Solvent has excellent colour (7)
12 Electronic device that's far from basic? (5)
14 Bones of oil baron finally claimed by Gulf state (5)
16 People may be caught by this motivational phrase, quietly (7)
19 See 5 Down
20 Enjoys sauces (8)
22 Designed as art, gummy bear releases energy in huge explosion (5,3,5)

DOWN

1 Cleric cutting carbon soon (4)
2 In France, 1000 tonnes of cereal (6)
3 Primate found in Malaysia mangroves (7)
4 Wander like some dogs (5)
5/19 Across Amphibian went off after small insect, catching nothing (6,4)
6 One man is on treatment for trouble in the bedroom? (8)
11 Tree in California sierra features on some volcanoes (8)
13 My colleagues and I bypassed road to get fish (7)
15 Thyroid hormone originally involved in cases of arthritis, malaria and respiratory condition (6)
17 Time to give out biological material (6)
18 In India, a large quantity of chromium mineral (5)
21 Alleviate diseases to some extent (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #191

set by Bethan Ackerley

1 In botany, the stalk that attaches a leaf to a plant's stem is known as what?

2 In what kind of celestial body would you find a tachocline?

3 The infection thrush is caused by fungi of which genus?

4 Who is credited with inventing the slide rule in around 1622?

5 What is the atomic number of uranium?

Answers on page 55

Puzzle

set by Peter Rowlett

#211 Cross purposes

Debbie and Hoi are playing a game where they take turns to cross out numbers written on a piece of paper.

Each player must cross out a divisor or a multiple of the number most recently crossed out. The first player who is unable to cross out a number loses.

Hoi goes first and crosses out 11. Debbie smiles, knowing she can now win in three moves. What number does she cross out?

2 3 4 5
7 ~~11~~ 15 19
33 35 38 51
55 76 77 95

Solution next week

Feeling light

On the night side of Earth, the sun's gravitational pull on me will be additive to that of Earth, whereas on the light side it will be subtractive. So, do I weigh more at night?

Mike Follows
Sutton Coldfield, West Midlands, UK

The answer depends on your location, your distance from the centre of Earth and any local variation in gravitational field strength due to the density of underlying rock.

Crunching the numbers, the weight of someone living on the equator would increase by about 0.1 per cent when on the dark side of Earth compared with the lit side. For a person with a mass of 62 kilograms this equates to a gain of around 70 grams – roughly the mass of a hen's egg and certainly less than the fluctuations in your mass due to what you ingest or eliminate throughout the day.

This calculation takes into account the fact that Earth's axis is tilted by about 23 degrees. If Earth were tilted at 90 degrees, there would be no diurnal variation. If you are at the same latitude as the UK, the diurnal variation in mass would be down to about 20 grams.

Celestial mechanics are complex and my calculations have omitted the effect of motion, but it is worth noting that Earth's spin will make you about 4 per cent lighter at the equator than at the poles.

> "The weight of a person at the equator would increase by 0.1 per cent when on the dark side of Earth compared with the lit side"

@dudnees
via Twitter

Weight depends on the distance from Earth's centre of mass. This increases on both the light side and the night side because the tidal effect of the sun stretches Earth in the sun's direction. So, you weigh less on both the light and night sides compared with your weight at sunrise or sunset.

Michael Paine
Sydney, Australia

The question is similar to "why are there two tides per day?" The answer is that centrifugal acceleration needs to be taken into account. In the case of tides, Earth and the moon revolve around a common centre of gravity – their barycentre. This creates a small centrifugal acceleration that is strongest on the opposite side of Earth from the moon and causes the tides to rise there. Conversely, the pull of the moon's gravity is strongest where the moon is overhead, so the tides rise at that point also.

The same effects – gravity and centrifugal acceleration– apply to Earth and the sun. So, on the night side of Earth, the sun's gravity will be weaker, but this is balanced by the greater centrifugal acceleration. The opposite occurs on the day side. If these effects didn't balance, Earth would dive into the sun or fly off into space.

Eric Kvaalen
Les Essarts-le-Roi, France

No, because when you are on the side of Earth away from the sun, the centrifugal force away from the sun is greater. This effect is equal to the extra gravitational pull from the sun on the sunny side of Earth. At sundown or sunrise, you weigh more.

The same thing happens with the moon. When the moon is high or beneath your feet, you are lighter, and when the moon is on the horizon, you are heavier. The moon's influence on your weight is about two times greater than that of the sun.

In any case, the effect is small. If you weigh yourself on scales with springs, the differences in the readings would be just a few milligrams. But, of course, if you weigh yourself on scales that use sliding weights, as in a doctor's office, you would be measuring mass, not weight. There would be no difference at all due to the sun and the moon, but only due to changes in your mass between different times of the day.

@PrideOfHumility
via Twitter

That is a lot of variables! Solar, lunar, oceanic and terrestrial tides, even magma displacement. Maybe the question should be: "If Earth were a giant, smooth, barren, glass marble of uniform density with no moon, would I weigh more on the night side than the day side?"

ENRIQUE DÍAZ/7CERO/GETTY IMAGES

Is there a reason why the gears and chain of a bike are located on the right-hand side?

This week's new questions

Turning right **Why are the gears and chain always on the right-hand side of bicycles?** ***Mark Holker**, Braunton, Devon, UK*

Hiss off **Cats, geese and snakes hiss, and angry audiences hiss to make their feelings known. How is it that this "language" is common to such diverse creatures, as well as to those who understand the warning?** ***Alan Stanton**, Birmingham, UK*

Eardrum symphony

How can a vibrating eardrum convey the rich symphony that we hear? Why don't the various frequencies interfere with each other?

James Stone
University of Sheffield, UK

The clue to the answer is in the second part of the question, which mentions "various frequencies".

In 1822, French mathematician and philosopher Joseph Fourier effectively proved that every sound can be represented as the sum of sinusoidal waves, each with a different frequency.

A sinusoidal wave is a pure tone and sounds like a single note on a whistle. As an example, if five sinusoidal waves with different

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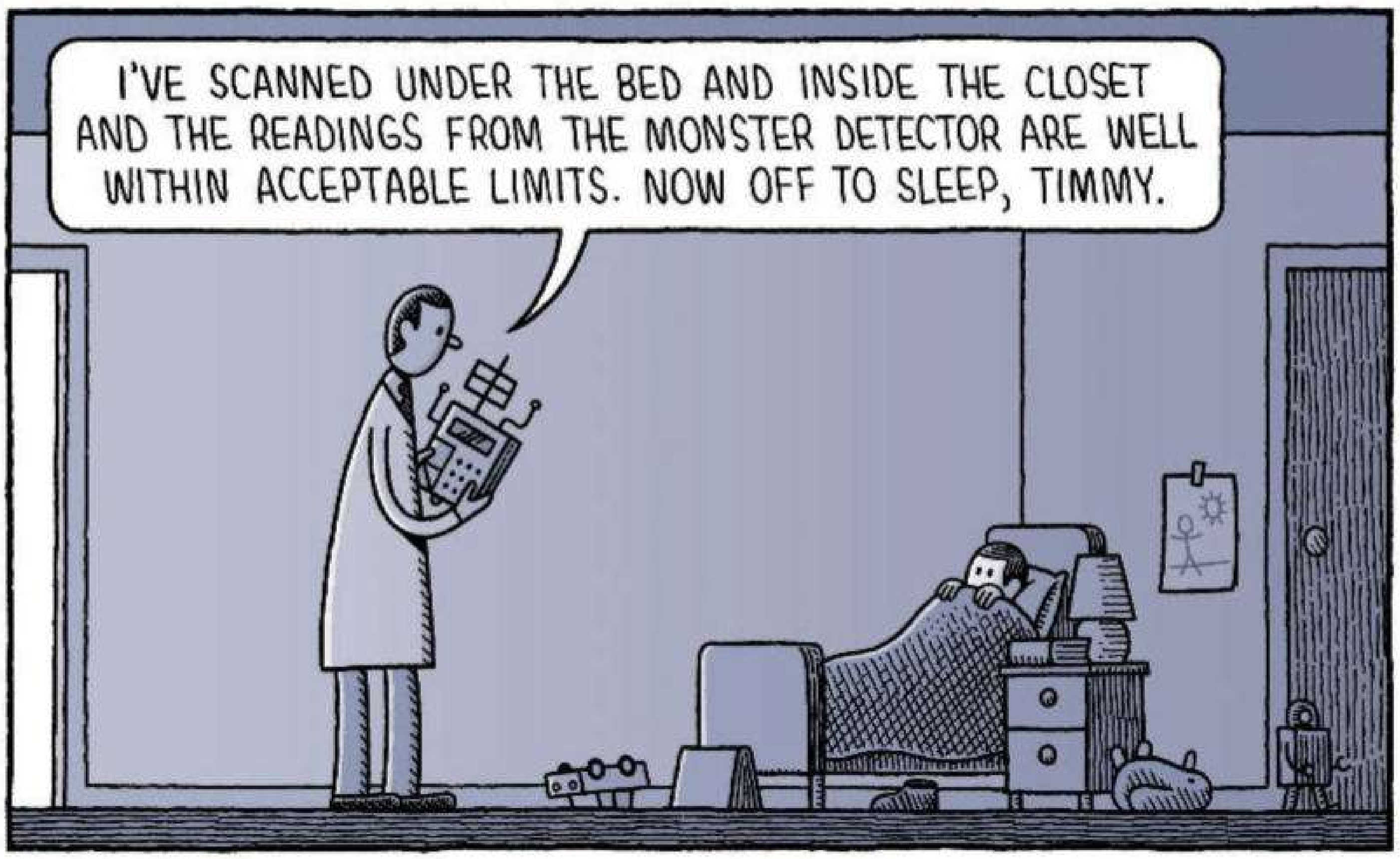
I'VE SCANNED UNDER THE BED AND INSIDE THE CLOSET AND THE READINGS FROM THE MONSTER DETECTOR ARE WELL WITHIN ACCEPTABLE LIMITS. NOW OFF TO SLEEP, TIMMY.

frequencies are added together, they produce a complex wave. It is obvious this consists of five sinusoidal waves because that is how it was made.

Once we know this, we should be unsurprised to learn that a part of the inner ear called the cochlea essentially separates out the various sinusoidal waves in any complex sound.

Origin of the bang

In which direction in the sky did the big bang take place 13.8 billion years ago? (continued)

Alfred Vouk
Hubbards, Nova Scotia, Canada
My take on this question is: imagine your body (immortal, of course) as a particle that originated in the soup of the big bang 13.8 billion years ago.

As the universe expands, it should be immediately obvious that there could be no direction one could look in the sky for the origin, as our immortal body is still inside this greatly expanded – and still expanding – soup, which now consists of the planets, stars and galaxies that surround us.

> **"Imagine your body (immortal, of course) as a particle that originated in the soup of the big bang 13.8 billion years ago"**

Martin Buote
Fall River, Massachusetts, US
This supposes an observer outside the space of the big bang. But we are within this space. When we observe something at a distance of, say, 10 billion light years, we are seeing the "now" of that thing 10 billion years ago, not a glimpse of our own history.

Ten billion years back in our own history would show a similar young universe where we stand now. Thus, our section of the cosmos was in the big bang billions of years ago and that big bang keeps expanding as if it were the surface of a balloon encompassing the entire universe.

Instead of being propelled out of the big bang, the big bang is receding from us in all directions, leaving behind the bits and pieces that coalesce into the quarks and so on that form our reality.

To put it another way, the possibility of employing the concepts of frame of reference, location and coordinates only came into existence within the big bang with the creation of space. Thus, the question of the direction from our present location to the site of the big bang is nonsensical. Our existential history is embedded in the big bang.

Philippe Martin
Paris, France
In a previous response, Stan Williams referred to a quote on the wall of a church in Aberdeenshire, UK: "The universe is a circle whose circumference is nowhere and whose centre is everywhere."

No need to visit this church, however, as this is simply a version of a quote from French mathematician and philosopher Blaise Pascal's *Thoughts*. ▮

Answers

Quick quiz #191
Answers

1 The petiole
2 A star
3 *Candida*
4 William Oughtred
5 92

Quick crossword #127 *Answers*

ACROSS 7 Zeppelin, **9** Loa loa, **10** Lion, **11** Copenhagen, **12** Albedo, **14** Less than, **15** Robots, **16** Gamete, **19** Ethylene, **21** Armour, **23** Stalactite, **24** Mode, **25** Tongue, **26** Immature

DOWN 1 Aerial, **2** Spin, **3** Blackout, **4** Clones, **5** Data stream, **6** Home page, **8** Napalm, **13** Embryology, **15** Rotation, **17** Analemma, **18** Gemini, **20** Exceed, **22** Udders, **24** Meta

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#210 Action station
Solution

I will catch the train… just!

If I am walking or running at a constant speed, I lose or gain time at a constant rate per unit distance. If I were to walk the whole way, I would get to the end point 10 minutes later than I wanted to, and I would get to the midway point 5 minutes behind. Similarly, if I ran the whole way, I would reach the end 15 minutes ahead and the midway point 7.5 minutes ahead. That means I am a net 2.5 minutes ahead by running half the distance and walking the rest of the way. I lose 2 minutes when hunting for my running shoes, which means I arrive half a minute before the train leaves.

Moss excitement

"It's not every day you can watch moss grow!" says a press release from the University of Wollongong (UOW), Australia. Too true.

The details in the press release lead to an invitation. The details: "In a world first, a team led by UOW researchers has developed a webcam (MossCam) and smart sensor system in Antarctica to remotely monitor moss beds, providing scientists with invaluable and continuous images and data about the Antarctic environment… The UOW team co-designed an Artificial Intelligence of Things (AIoT) platform." The invitation: "You can view the MossCam and data the smart sensors are collecting at: https://uow.to/mosscam".

Feedback has made many attempts to view the MossCam and data. But no joy. No moss. The link produced only the message "This site can't be reached". Maybe the press release was too effective. The public demand to watch moss grow overwhelmed the technology, maybe.

Twisteddoodles *for New Scientist*

THE ZOMBIES ARE INFECTED WITH AN UNUSUAL STRAIN OF LEPIDIUM SATIVUM
GARDEN CRESS?
BUT HOW WILL WE KNOW WHO IS INFECTED?
OH. YOU'LL KNOW
EGGGG
@twisteddoodles

Got a story for Feedback?
Send it to feedback@newscientist.com or
New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Academic theft

University of Sydney astronomer Charlie Sharpe takes time (and space) in a new study to thank the New South Wales police "for ensuring a swift return of his belongings, including his laptop, after having them burgled from his house a few weeks before this paper's submission".

Sharpe also thanks his "neighbour, Gary, who spotted the burglar and, rather than simply phoning the police and staying put, decided to yell 'you better run fast mate' before chasing the man down the street, tackling him, pinning him to the ground, and *then* calling the police, all while still in his pyjamas and a sleepy daze".

Sharpe's paper, co-written with two colleagues, is called "On cosmological low entropy after the big bang: Universal expansion and nucleosynthesis". It asks "What light do the fundamental laws of nature shed on the arrow of time?"

Some years ago, Chris Trayner at the University of Leeds in the UK looked at a commonly used anti-burglar technology, asked what light it shines on astronomy, got riled at the answer and proposed to do something about it. It being security lighting that is triggered by motion outside a building.

Trayner explained the problem in a short entry in the *Journal of the British Astronomical Association*, and proposed a solution. His view of the issue: "At least two criticisms are levelled at these lamps: (1) they pollute the night sky with light; (2) no-one takes any notice of them turning on, so they merely save burglars the cost of torches."

Trayner's solution: get the movement sensor to turn on a light inside, rather than outside, the building. "If a burglar triggers it, it gives the impression that a householder is up and about… [and] since the indoor bulb is of moderate brightness, little light pollution results."

Here we go again

The phrase "Knowing Me, Knowing You" appears in the title of many scholarly publications, and also a song by a Swedish singing group.

One of the newest research reports to do this is called "'Knowing me, knowing you': Personalized explanations for a music recommender system". It shares little – except those four words in its title – with a study called "Knowing me, knowing you: Self and non-self recognition in plant immunity".

There are "Knowing me, knowing you" reports on many topics. One is about whether artificial intelligence is aware that people have minds. At least one report looks knowing-me-knowing-you-ingly at how the anal gland secretion of European badgers relates to their membership in social groups. A University College London team published an 11-pager titled "Knowing me, knowing you: The role of trust, locus of control and privacy concern in acceptance of domestic electricity demand-side response".

Well more than 200 scholarly publications, so far, have the six consecutive syllables know, ing, me, know, ing and you as part of their title. As for the song: it was released as a single way back in 1977. The academic versions all came later.

Priority for putting the phrase in a title pretty clearly belongs to Agnetha Fältskog, Björn Ulvaeus, Benny Andersson and Anni-Frid Lyngstad, who made a name for themselves with that song, and earlier by cobbling together the initials of their first names.

Tandoori safety

There are no sure things in life, probably. Food technology experts, like other kinds of experts, find ways to express the certainty that something is probably certain. The National Institute of Food Technology Entrepreneurship and Management, in Sonipat, Haryana, India, supplies a new example, with the concluding assertion that "the consumption of tandoori chicken may be considered as safe". Nineteen pages of details accompany that simple declaration, all of it published in the journal *Risk Analysis*.

The report ends with a neighbourly caution about its reliability. The certainty of it – of its conclusion – pertains to people whose diet is entirely and exclusively chicken. "This," say the researchers, "is a major limitation which needs to be addressed in future studies." ▮

Marc Abrahams

GALAXY
ON GLASS

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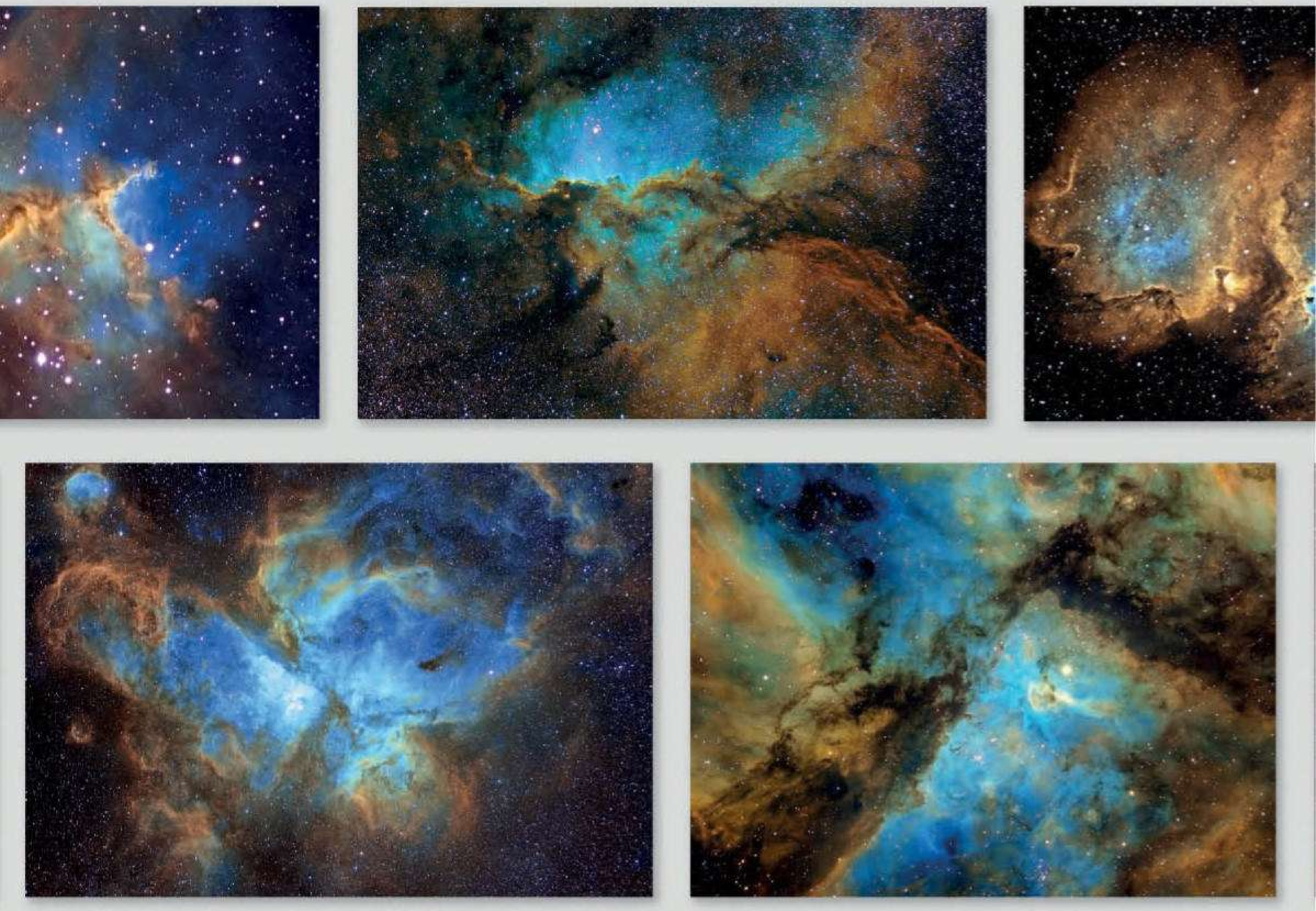

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